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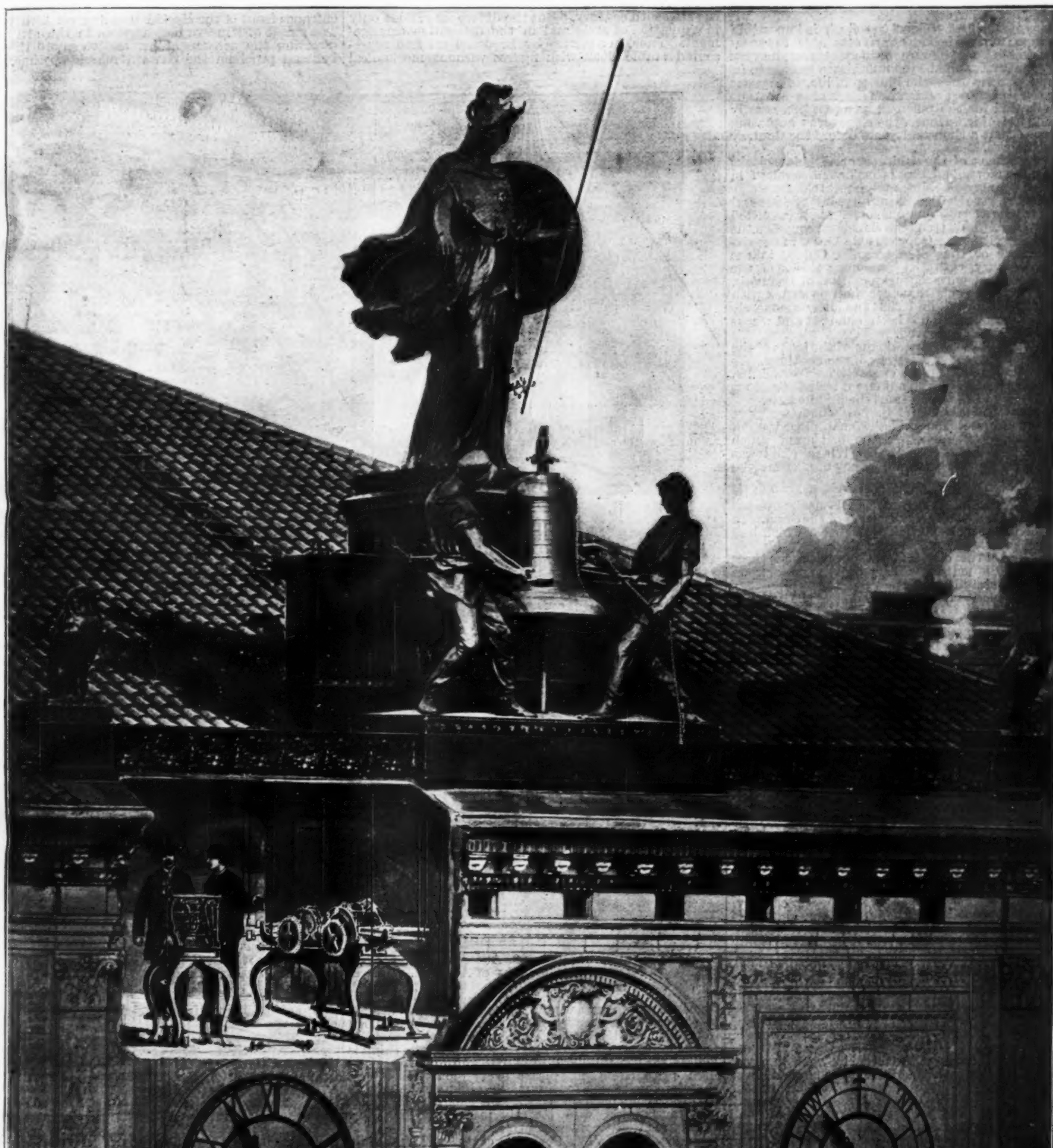


THE HERALD ESTABLISHMENT, NEW YORK—THE STATUE OF MINERVA, BELL GROUP, AND CLOCK.

CLOCKS PROVIDED WITH AUTOMATONS.

To speak of "jack o' the clock" is in most cases to call to memory the figures of the belfry of the church of Notre Dame of Dijon, where they have struck the hours ever since Philip the Bold placed them there, after removing them from Courtray in 1382, after the battle of Rosbecque. It would seem as if such figures were the primitive type, par excellence, of the kind, and as if it were from them that proceed all the other jacks o' the clock or automatons. This is not the case, however, and the figures of the church of Dijon are interesting for the particular reason that they were the first set in motion by weights substituted for water, which had been utilized up to then in the old clepsydras. They therefore mark the starting point of this sort of clockwork in Europe, for automatons, like those of the celebrated clepsydra of Charlemagne, for example, had up to then been applied only to western clocks, or at least had remained unknown.

The history of jacks o' the clock or automatons in clocks therefore comprises two periods: the first is that of clepsydras and the second that of clocks with weights or springs. One dates from a certain antiquity, while the other begins with the kind of clocks of which we are speaking and has been perpetuated, with various transformations, up to our day.

The date of the first jacks o' the clock is impossible to determine; but as soon as man was able to represent an animate being by any means whatever, he very probably must have tried to communicate motion to it, in order to give his work the illusion of life, to as great a degree as possible; and when he had a constant motion adapted for the purpose, he must necessarily have made use of it. Hence, the clepsydras actuating figures more than a thousand years before the Coutray clock was known.

The automatons of the Chinese or Arabian clocks were the precursors of all those that have been used in our western country in belfry and mantel clocks.

The subjects have varied to infinity, but the general characters of the first automatons have been transmitted from age to age. This is so true that if we compare the clepsydras described by Choricius de Gaza in the sixteenth century or that of Y-hang, in China, in the eighteenth century, with the Strasburg clocks of the fourteenth and sixteenth centuries or that of Beauvais, which is contemporary with us, we shall be struck with the similitude and shall find that the latter are merely clepsydras whose motor has been changed and whose mechanism has been improved.

We shall not draw up a catalogue of the jacks o' the clock of Europe, nor give a history of each of them. We shall merely refer to a few as characteristic examples, and shall afterward follow the different transformations of this accessory of the clock since the middle ages.

The jacks o' the clock of Dijon of which we have spoken were at first a man and a woman placed upon an iron framework supporting the bell upon which they struck the hours (Fig. 1). In 1714 a child was added for striking the quarters. They are, as may be seen, quite simple.

At Cambrai, Martin and Martine are represented by two Moors. At Lunden, in Sweden, the clock actuates two horsemen as well as an adoration of the Magi. In 1405 was constructed the clock of Lubeck, which had the Twelve Apostles.

In the belfry of the city hall of Compiegne are three warriors called Piquentins, which strike the hours upon three bells placed under their feet (Fig. 2).

In the Gothic lantern which terminates the belfry of Avignon two figures, those of a man and a woman in the costume of the country, strike the hours (Fig. 3).

Three remarkable jacks o' the clock are those of the clocks of Nuremberg and Berne. Francis I constructed at Fontainebleau a clock in which were seen seven figures of natural size representing Apollo, Minerva, Mars, Mercury, Jupiter, Venus and Saturn, personifying the days of the week. Vulcan sounded the hours. At the Castle of Anet, under Henri II, a hind struck the hours with one of its hind feet, while two dogs yelped at his sides. At Clermont-Ferrand there is a clock in which is seen a Mars, a Faunus and a Time.

At Medina del Campo, kingdom of Leon, there was a clock in which two rams struck the hours by butting with the head.

Among monumental clocks, we may mention that of St. John of Lyons with its statuettes striking the hours and others representing the days of the week; then that of Strasburg, so often described.

Belfry clocks with automatons fell into disuse in the seventeenth century, and it is only exceptionally that they have since been constructed.

House clocks, as long ago as the fifteenth century, were sometimes provided with automatons, and these pieces were of wood or iron. Of these latter, we have an example in the clock that still exists in the Cluny Museum, and of which the human figure placed above the dial moves its lower jaw when the hour strikes.

The custom of constructing clocks with wooden figures is preserved in Swiss and German clocks, which are still made in our day; but it would be an error to believe that this kind of automaton is of German origin. This country has simply preserved the tradition of them.

The sixteenth century brought in with it great progress in the construction of the movement of house clocks, and notable improvements in that of the automatons

The Renaissance was the age par excellence of small complicated timepieces. The clocks with automatons which had been made only of wood or iron were then made of copper, and were capable of being placed upon a table. Certain of these were genuine chefs d'œuvre for the epoch, and constituted objects of the greatest luxury, in which the art of the clock maker gave itself full sway.

Among other valuable and complicated kinds, there were ships containing numerous people. They were composed of figures that performed many mechanical functions. The interest that such pieces offered was increased by the richness of their decoration, in which gold, silver and enamel were mingled.

The ship of Charles V, which is now in the Cluny Museum, shows a very beautiful specimen of them. It was designed to serve as an epergne. It is mounted upon rollers, and the mechanism of the motion causes it to advance and recede. Such pieces were highly prized in the sixteenth century. They were very costly. They were even the objects of gifts among sovereigns (Fig. 4).

More common were the clocks, properly so called, with moving figures. Some were made with hunting scenes, others with figures representing the days of the week, others with statuettes striking the hours upon a bell like true jacks o' the clock, etc.; but in these pieces the very small statuettes were somewhat lost in the ensemble of the clock; so some were made whose automaton itself was the principal motif, and in which the part devoted to the movement as well as the dial became secondary. These pieces represented persons or animals placed upon stands. In our collection there is a Turk on horseback who moves his head and arm, while the horse moves his eyes and tail. The human figure is of gilded bronze, and the stand is of ebony (Fig. 5).

We own also a Virgin of gilded bronze mounted upon an ebony stand in which the movement is concealed. The hours are engraved upon the band of the crown that surmounts the head of the statue, and every hour presents itself successively in the center of the Virgin's forehead.

From the clock with automatons of the Renaissance proceeds the clock with subjects. The subject of the Louis XIV clock is evidently not the same as that of the sixteenth century. But the difference resides only in a question of style and in the decorative arrangement. Thus, in a picture by Breughel we find represented a table clock with figures without mechanical function, which, aside from the taste that presides in its construction, exactly constitutes the subject clock in the conventional sense of the word (Fig. 6). We might multiply such examples. Moreover, the thing is logical, for the puerile side of the automaton and its high price could not please every one. There was, therefore, no reason for not making immovable figures for decorating parlor clocks. The small table clocks with automaton were scarcely made any longer in Germany after the seventeenth century.

Under Louis XIV, however, clocks with multiple figures came rapidly into favor again. The king had a great predilection for them.

The clock hall at Versailles still preserves some sumptuous types of them. There was also seen at the court of the king a clock consisting of a gilded bronze woman clad in a drapery of silver, having back of her a monkey, and she herself sitting in a chariot drawn by two leopards. The whole was set in motion by a spring concealed in the chariot. But this piece was older than the epoch under consideration. It, or a counterpart of it, is now to be seen in the Museum of Industrial Arts of Milan (Fig. 7).

In the clocks of the eighteenth century, the automaton underwent still another transformation, and, instead of being in high relief, the figures were made of flat metal plates simply cut out in silhouettes and either engraved or painted.

In our collection there is a clock of the same kind representing a village scene in which there is a violinist with a jointed arm holding a bow with which he plays upon the violin. Before him dances a person whose legs likewise are jointed. It is to the sound of the chime, of the movement that strikes the hour and the half hour, that all is set in motion. During this time, small boats pass across an aperture formed in the center of the dial (Fig. 8).

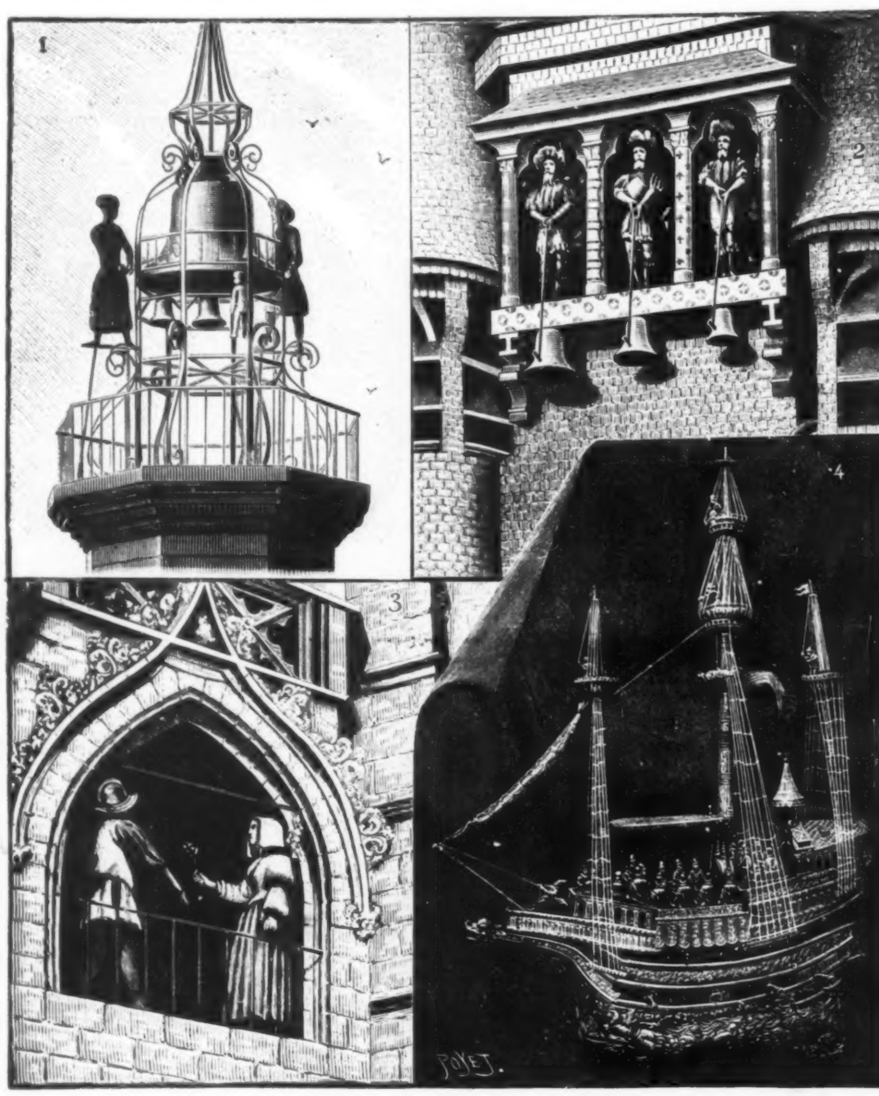
From such clocks were derived the one whose subject is inclosed in a carved wood frame gilded and protected by glass. The back of the picture generally represents a landscape, say a village or any other subject with an edifice admitting of a dial marking the hour.

Another kind of clock that found favor in the eighteenth century was in the form of a cage containing mechanical singing birds. . . . The dial of these cage clocks was placed beneath, so that the time was seen when they were suspended from the ceiling of a room.

For the illustrations we are indebted to La Nature. We also illustrate the bell automatons on the New York Herald building.

Our first page plate is a photographic representation of the beautiful group of statuary which adorns the entrance front of the Herald building on 35th Street. The statue of Minerva here appears in the attitude of directing the artisans at her feet to sound the great bell and proclaim the onward march of time. This group of statuary is from the chisel of Antonin Jean Carles, the distinguished French sculptor, whose many admirable works are well known, and some of them were exhibited at Chicago. The bronze workmen shown in our group are movable figures, operated by machinery, and as the time comes around their bodies sway, the hammers move, and the bell sounds the hour. The bell, however, is not actually struck by these moving figures, but by a special hammer located at the back of the bell.

The machinery by which the bell is sounded and the clock mechanism driven is shown in our plate, just above the clock face. One of the machines operates the clock, the other works the figures. The connecting rods can be traced by an examination of the plate. This mechanism is by the Howard Clock Company, of Boston, Mass., and its accurate working gives much satisfaction.



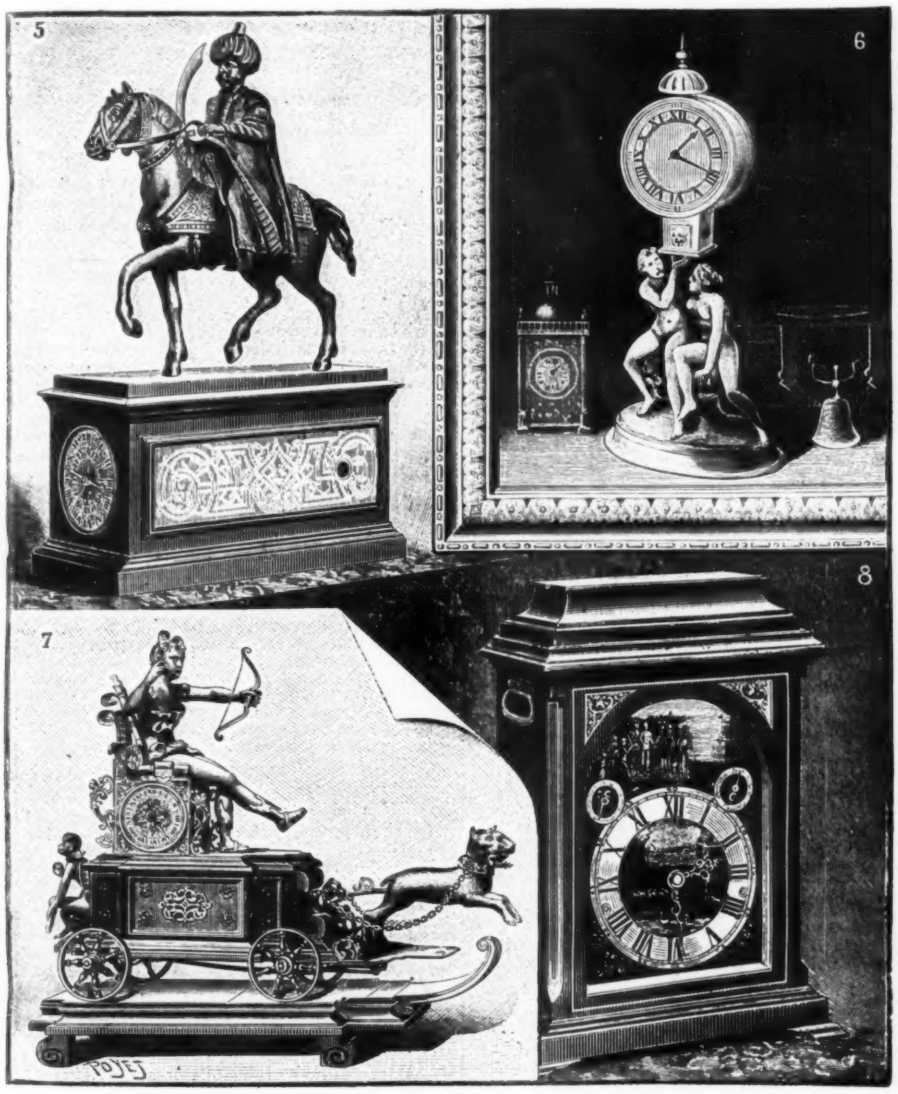
FIGS. 1 TO 4.—CLOCKS WITH AUTOMATONS.

1. The clock of Dijon. 2. Automatons of the clock of the City Hall of Compiegne. 3. Gothic clock in the belfry of Avignon. 4. Boat of Charles V moving upon a table.

PUMPING HOT WATER.

How high will a pump lift water, and how high can hot water be lifted by a pump? are questions which continue to be animatedly discussed by engineers, and some statements on this subject have been made which, to say the least, are quite remarkable. Theoretically considered, cold water may be lifted by so-called suction 33·9 feet above the surface of the supply, but

owing to the defects of machinery we find that in practice, under highly favored conditions, water can be lifted in this manner to a height of only about 27 feet. Special apparatus, says an American paper, might do better than this, but ordinary devices never do. All pumps are constructed with valves, and those valves have a certain weight which must be deducted from the pressure of air by which the water is forced above its level; for the action of a pump, primarily, there is nothing more than exhausting the air from above the water. A portion of the loss of duty in a pump is due to leakage, even when in the best practical working condition, so that ordinary leakage and weight of valves limits the lifting power of an ordinary pump to 27 feet of water or a column equaling 11·7 pounds in weight per square inch of cross section. The next question that arises is, At what temperature will a pump lift water to this height? Practical experiment has repeatedly shown that when the water has a temperature of more than 50° Fah. it cannot be lifted to the same height by the same pump, and the reasons for this are that there is an unbalanced air pressure of 3 pounds remaining in the pump, and that the vapor given off from the water at that temperature is sufficient to fill a portion of the space and prevent the water rising to that height. When water under an atmospheric pressure of 3 pounds is transformed into vapor, the volume of vapor produced is so many times greater than that of the water that only a small volume of water is sufficient to produce vapor which will fill an change of condition, the temperature is reduced to such an extent that the water is rapidly frozen and becomes solid ice. Water when at a temperature of 98° will boil in a perfect vacuum, the heat contained in the mass being given up and transforming a part of the water into steam. A vacuum sufficiently perfect to produce this effect on water of 98° temperature is not easily obtained, owing to the imperfection of the apparatus; but with reasonably good pumps, or other means of reducing the air pressure, water at a temperature of 100° can easily be made to boil by such a reduction of the air pressure as can readily be obtained. In attempting to lift hot water, or water of a temperature above 100°, the height to which it can be lifted cannot be readily calculated on account of the invisible vapor given off from the surface and filling a portion of the space before boiling commences. When water at 100° is changed into steam at 100° the volume is increased nearly 3,000 times; so it will be readily understood that if the pressure of air is relieved to such an extent as will permit the water to boil, the vapor resulting from such action would fill the suction pipe and cylinder of the pump, and its further action would be expended on the elastic force of the steam, so that the water could not be lifted above a certain height; but that water of a much higher temperature can be lifted certain distances will be readily understood by considering that, if the pressure of air within the pipe be relieved to a certain extent, the superincumbent pressure of the atmosphere on the water which forms the supply will force it upward in the pipes to a height due to the difference in pressure, excepting that, at all temperatures, water gives off a vapor when the pressure on its surface is reduced. To illustrate, suppose we take water at a temperature of 143°, which will boil under a pressure of 3 pounds absolute; then if we reduce the pressure on its surface to nearly this amount, we will have an unbalanced pressure of about 11·5 pounds to force it upward in the pipes, which it would do to a height of about 26 feet were it not for the vapor given off, which fills the space and makes it impossible to retain the reduced temperature with water at that temperature. The best pumps have a lifting efficiency of only about 80 per cent. under favorable conditions of operation, and this includes that the water be of the lowest practical temperature, so that instead of an unbalanced pressure of 11·5 pounds being sufficient to force the water to a height of 26 feet, practice demonstrates that 12 feet is the greatest height to which water at 140° can be lifted by a so-called suction pump, and as the temperature of the water is increased, the height to which it may be lifted decreases in a much greater ratio. All accounts of lifting water having a temperature of 200° and upward, by suction pumps, must be taken with a great deal of allowance for incorrect observation and mistaken data.—Invention.



FIGS. 5 TO 8.—AUTOMATON CLOCKS.

5. An automaton of the sixteenth century. 6. Automatic clocks (from a picture by Breughel) 7. Automatic Diana. 8. Clock with moving figures of the eighteenth century.

exceedingly large space and be sufficient to prevent the full action of the pump. Under these conditions the vaporization of a very small portion of the water would be sufficient to fill the suction pipe and cylinder of the pump, but this would not be necessary to prevent it working, as if only the 100th part of the water is vaporized—and there is sufficient heat present to provide for the vaporization of much more than this amount—the vapor produced will prevent the water being raised to the height of the pump, if it is about 27 feet above the surface of the water. As the temperature of the water is increased above this, the height to which it can be raised will decrease in a corresponding ratio. Of course, when we speak of lifting water to any such height as this, it is necessary that suction pipes, valves and pump plunger shall be absolutely airtight, a condition which it is quite difficult to obtain in practice without introducing other difficulties of greater moment, as, for instance, excessive friction in the pump cylinder, which will require a greater amount of work to overcome than that which is utilized in raising the water. That water gives off vapor copiously, when relieved of the air pressure upon its surface, is shown by laboratory experiments, where a shallow dish of water is placed under the bell glass of an air pump and the air pressure reduced; vapor is given off so rapidly that by its absorption of heat, owing to its

[Continued from SUPPLEMENT, No. 1080, page 17265.]

CHAINS AND CHAIN IRON.

By G. N. SHAWCROSS.

RONGIER'S PROCESS.—Another form of making weldless stud chain by stamping is that of M. Rongier. The chain is formed from a specially rolled bar, of which the section is a cross with arms of equal length. The links are eggshaped, and have solid studs. These studs, together with the absence of welds and the homogeneity of the metal, tend to make it exceedingly strong, and its resistance is still further improved by subjecting the links to pressure. There are ten processes, of which all but two are automatic, and all are applied to the cold metal. The inventor claims to make ½ in. chain at a total cost of £16 10s. per ton, or 16s. 6d. per cwt. According to tests made at Lloyd's, the chain was equal in strength to a 1 in. welded studless chain, costing £12 per ton of 210 ft., against 558 ft. per ton of the ½ in., thus showing the chain to be 50 per cent. cheaper for equal strength.

Another way of making chain links is by means of a pair of dies, the bottom one, which is fixed, having in its face a U-shaped groove, constructed to receive the end portion of the link to be welded, while the upper or moving one is a counterpart of the lower one. Each link is welded separately, and after each stroke it is necessary to turn it over on the die, so that both sides may be subjected to the stroke of the top die. As the dies are so made that one end is closed, the end near the workman being open, the part of the chain already formed is drawn out, in order to turn a portion of the chain. This takes up considerable time and adds to the cost of manufacture. Another drawback is that the upper die, on coming in contact with the lower one, is apt to move endways, and so cause the links to be somewhat distorted.

Herman's Chain.—Another form of chain is that of Herman. This chain, shown in Fig. 5, which is weldless,

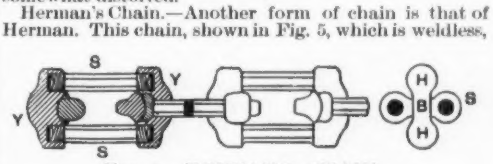


FIG. 5.—HERMAN'S CHAIN.

consists of four separate parts, viz., two straight side bars, S S, and two end pieces of yokes, Y Y. The side bars are made octagonal, so as to facilitate the separating of the links. Each bar has its end enlarged and threaded, one with a right hand, and the other with a left hand thread. The yokes, Y Y, consist of a center part called the beam, B, and an enlarged part at each end known as the head, H H. The side bars are screwed into the holes at H H. At B B, in Fig. 5, the beams of adjoining links are shown in cross section. The inventor claims that a chain made of these links is perfectly flexible at each joint, and, as in all chains, the load is transmitted from link to link at the center of the yoke. From here the strain passes by means of the screw ends into the side bars.

The side bars require to be made of metal of high tensile strength, and must be fairly tough, so as to stand a considerable amount of use without serious injury. Herman states that tests made on this chain show an ultimate strength of 97 to 99 per cent. that of the side bars, and that every link tested failed in the side bars, but he says nothing about the cost of this kind of chain, which would be rather expensive.

Forms of Chain.—In Figs. 6 to 9 are four different kinds of chain, viz., the single jack, double jack, open welded, and triumph. In 1893 Professor Hele Shaw made a series of experiments on these forms of chain, and found that for equal sizes in small chains the strength of the triumph chain was double that of the ordinary welded chain, 5 times of the double jack and 11 times the strength of the single jack chain. Among others he took samples of the above of 0·23 diameter or bare ¼ in., and found that the strength of the triumph chain was 3,770 lb., or 1·68 tons, compared to 1,990 lb. for the welded chain and 790 lb. for the double jack chain. A further test was made by twisting a piece of wire to the form of the triumph chain, and then breaking the link, and afterward a part of the wire from which it was formed. The test so made showed that the stress required to break the link was 1·75 times that of the single wire.

Samples of Chain.—In addition to these tests, the author has made a series of tests on the following kinds of chain, viz., the American triumph, steel weldless, twisted, and B B B short link welded chain, and found that for equal sizes the breaking weight of the various samples was as follows. In each case the mean of six tests has been taken as fairly reliable.

Diameter.	No. 4 triumph.	Steel weldless.	Twisted.	B B B short link.	Board of Trade requirements.
0·29 in.	3 tons.	3·6 tons.	1·57 tons.	2·09 tons.	1·5 tons.

So that the various kinds will be classed thus:

1. Steel weldless chain, which is 140 per cent. stronger than B T
2. Triumph chain " 100 " " "
3. B B B short link " 39·3 " " "
4. Twisted chain " 4·6 " " "

The triumph chain is made of high carbon Bessemer or Siemens steel wire, and may be twice as strong as the Board of Trade requirements for a corresponding size of welded chain, but it is certainly not twice as strong as the chain itself, for B B B short link chain is, as a rule, 40 per cent. stronger than the B T requirements. Triumph chain will become distorted under a load which welded chain will withstand without detriment. The author has also made tests on the strength of dollied chain compared with chain that has been hammered only. By dollied chain is meant chain which, after being welded, is made round and smooth by using the dolly shown in the sketch of the smith's anvil. In these tests ¼ in. diameter chain was taken, and it was

found that dollied chain had an average breaking weight of 2·26 tons, compared with 2·08 tons for hammered chain, a gain of 8·6 per cent. in favor of dollied chain. In $\frac{1}{4}$ in. twisted chain which has been dollied the breaking weight was 1·63 tons, or 5·09 per cent. stronger than hammered twisted chain.

In addition to short link or crane chain, there is another style of welded chain, known as "long link." This is usually one and a quarter times the length of short link chain of the same diameter, and is used for drag and shunt chains and all articles used for hauling purposes where a chain of great strength, like crane chain, is not so necessary. Long link chain weighs lighter per equal length than short link, and is somewhat cheaper.

Twisted chain is used for fitting up dogs, grabs, etc., and articles used for lifting purposes where the hooks are not fixed, but slide along the chain so as to take any breadth between them. By using twisted chain they slide along much easier than would be the case with ordinary link chain, where the links stand out at right angles to each other alternately, whereas in twisted chain the links are bent the same way, and present a smooth face, so to speak, to the ring of the grabs, etc., and so permit it to slide easily. This chain is tested to half the strength of short link chain of equal size.

The Admiralty test load on short link chain is two-thirds that of stud link, or say twelve times the square of the link in inches. Thus the proof load for 1 in. chain is 12 tons, and of $\frac{1}{2}$ in. $= (\frac{1}{2})^2 \times 12 = 3$ tons, and so on. The breaking weight of average chain may be taken at twice the proof load, or 24 times the diameter squared in inches. This gives a factor of safety of 4 between the working load and the breaking weight, as specified by the Admiralty or Board of Trade. A really good chain should stand a breaking weight 40 per cent. in excess of the Board of Trade requirements—that is, if a proper quality of iron has been used, and care taken in the making of the chain. When a chain is tested to destruction, it is liable to fail first across the weld or quarter near the weld; this seems to be the weakest place. In breaking a chain under a steady pull the links stretch, and gradually clinch one another until the chain fails, when they are so locked together as to seem like a solid rod of metal. This drawing out of the links is one of the warnings we get that the chain is unsafe, and ought to be taken down. If a chain be loaded suddenly, or jerked, it is liable to fail at once, and without notice, especially if it has been in service for some time.

One of the most confusing of all common breakages is that of a chain which has seen hard service. By that is meant one that has stood a series of shocks, vibrations, and strains due to varying loads for a long time. When a new chain is slowly pulled to its breaking

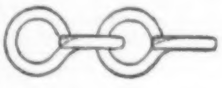
FIG. 6.


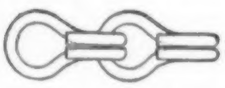
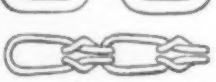
FIG. 7.


FIG. 8.


FIG. 9.


point, the fracture is generally of a fibrous nature, but after much service the chain will always break suddenly, with little or no stretch, and the fracture will be crystalline. It is then quite brittle, and will break off short, if bent. But if this chain be heated to a dull red heat for a certain time, and allowed to cool slowly, the material will undergo a change, and will be as tough as when first new, and will not show a crystalline fracture when broken as it did before. This proves that the iron has had a change in nature in some way since it was put into service. It is well known that repeated straining to a high degree makes a metal unfit for use. This, we say, is due to the metal becoming fatigued. This fatigue is partly overcome by means of annealing.

Annealing.—Every so often, usually about 12 months, all the more important lifting chains, such as those belonging to cranes, jiggers, etc., should be well annealed. This process consists of putting the chain into a furnace, and heating it to a good red heat, care being taken not to burn it. The time required for this depends on the thickness of the chain. It is then taken out and covered with ashes, or some substance to help it to retain its heat and cool slowly. This cooling process is very important, and upon it the whole benefit due to annealing practically depends. By this means the chain is rendered more ductile, and becomes tough. If a link be broken after annealing, the fracture will present a fine texture, totally different to the coarse crystals which often occur in the fracture of an unannealed chain. The effect of annealing is to make chains more reliable, but it does not add to their tensile strength. It also burns off any dirt or grease on the chain, and thus permits a more careful examination for flaws, etc. All chains should be tested again after annealing.

Repairs to Chains.—All important chains, such as crane and jigger chains, shear leg chains, etc., that have been in service should be taken down and sent to the repairing shop for inspection and testing at least every twelve months. Usually, the larger chains are sent once in six months. When received, they are first carefully annealed, and afterward examined. All faulty links found are then cut out, and a length of new chain put in to replace them. The worst wear takes place at the inside of the link where the next link binds it. Also, if the links are pulled and cause the chain to be stiff they are replaced. The chain is then taken to the testing machine, and a test load of twice the working load is applied to chains up to $\frac{5}{8}$ in. diameter, and about 70° in excess for chains over that size. The test load is calculated so as to give a fair test, and yet not too severe as to injure in any way. After testing, the links are again examined for spills, cracks at the crown, etc., which the test load may have set up. If satisfactory, the chain is then stamped on an end link with the test number, date of test, together with the proof and safe working loads. It is then greased, or else it receives a coat of tar by dipping it in a tank of tar sunk into the floor. After this process the chain is again ready.

Hooks.—In conclusion, before leaving this highly interesting subject, the author wishes to dwell very slightly on the question of hooks, which he considers are so closely connected with chains and play so important a part as to warrant their inclusion in this paper.

There is no detail of lifting tackle more distrusted by the average workman than the ordinary hook. Often when lifting a heavy weight he will lash together the nose and shank of the hook, in order to assist a part which ought to be of sufficient strength as to do away with such aid. It is not enough to say that a hook has withstood a certain test load to justify it carrying that load in practice. A hook that has been sprung by applying a load over the elastic limit will not always stretch again on a second application of the same load, but experience teaches us that a hook may stand a series of such loads without apparent injury, and yet fail suddenly under the very same load. Therefore we apply a test load, severe, but not enough to injure it with a few repetitions.

There are two classes of hooks, viz.: (1) Those made from rolled bars, bent and flattened to a wedge shape at the back; (2) hooks of circular section throughout, which are drawn out from the bar iron, and thus keep the fibers intact. In the case of swivel hooks, the best plan is to make the hook itself of mild steel of the first class, and the swivel, which has to be welded, of best hammered iron, for if made of steel the weld is always unreliable, no matter how careful the workman may have been. The author has seen many of these steel swivels which on examination seemed to have been soundly welded, but which pulled open on being tested showing the weld to have been closed only on the outside. Small hooks made by stamping have considerable strength, but, when they do break, fail with very little deflection.—The Practical Engineer.

ODOMETERS.

In the inventory of the objects sold after the death of the Emperor Commodus drawn up by Julius Capitolinus in the life of Pertinax, we find mentioned, among other valuable things, "vehicles that mark distances and hours."

Vitruvius (X, 14) describes the mechanism of these vehicles, but the figures that must have served to throw light upon the text have been lost, so that his description is somewhat obscure. Fortunately, as a sequel to a manuscript of the Dioptra of Heron, there have been found two Greek fragments upon this same subject, dating back probably to the Alexandrine epoch and accompanied with figures. The following is a translation:

TO MEASURE DISTANCES UPON THE SURFACE OF THE EARTH BY MEANS OF AN APPARATUS CALLED AN ODOMETER.

Provided with this instrument, instead of being obliged to measure land slowly and laboriously with the chain or cord, it is possible in traveling in a vehicle to know the distances made, according to the number of revolutions of the wheels. Others, it is true, have, previous to us, made known certain methods of accomplishing the same object; but every one will be able to decide between the instrument described here by us and those of our predecessors.

Let us imagine an apparatus in the form of a box (Fig. 1) in which is contained the entire machine that we are to describe. Upon the bottom of the box rests a copper face wheel, A B, having, say, eight teeth. In the bottom there is an opening in which a rod, fixed to the hub of one of the wheels of the vehicle, engaging at every revolution, pushes forward one of the teeth, which is replaced by the following one, and so on indefinitely. Whence it results that when the wheel of the vehicle has made eight revolutions, the face wheel will have made one. Now to the center of the latter there is fixed perpendicularly, by one of its extremities, a screw which, by its other extremity, engages with a cross piece fixed to the sides of the box. This screw gears with the teeth of a wheel whose plane is perpendicular to the bottom of the box. This wheel is provided with an axle whose extremities pivot against the sides of the box. A portion of this axle is provided with spirals formed in its surface, so that it itself becomes a screw. With this screw there gears a toothed wheel parallel with the bottom of the box. To this wheel is fixed an axle, one of the extremities of which pivots upon the bottom, while the other enters the crosspiece fixed to the sides. And this axle likewise carries a screw that gears with the teeth of another wheel placed perpendicular to the bottom. And this arrangement may be continued as long as may be desired or as long as there is space in the box; for the more numerous are the wheels and screws, the longer will be the route that one will be able to measure.

In fact, every screw, in making one revolution, causes the motion of one tooth of the wheel with which it gears; so that the screw carried by the face wheel, in revolving once, indicates eight revolutions of the wheel of the vehicle, while it moves only one tooth of the wheel upon which it acts. So too, the said toothed wheel, in making one revolution, will cause the screw fixed to its plane to make one revolution, and a single one of the teeth of the succeeding wheel will be thrust forward. Consequently, if this new wheel has again thirty teeth (and this is a reasonable number), it will, in making one revolution, indicate 7,200 revolutions of the wheel of the vehicle. Let us suppose that the latter is 10 cubits in circumference, and this would be 72,000 cubits, that is to say, 180 furlongs. This applies to the second toothed wheel. If there are others, and if the number of teeth likewise increases, the length of the voyage that it will be possible to measure will increase proportionally. But it is well to make use of an apparatus so constructed that the distance that it will be able to indicate does not much exceed that that it is possible to make in one day with the vehicle, since one can, after measuring the day's route, begin anew for the following route.

This is not all. As one revolution of each screw does not correspond with mathematical accuracy and precision to the escapement of one tooth, we shall in an express experiment cause the first screw to revolve until the wheel that gears with it has made one revolution, and shall count the number of times that the wheel will have revolved. Let us suppose, for example, that it has revolved twenty times, while the adjacent wheel has made a single revolution. This wheel has thirty teeth. Therefore, twenty revolutions of the face wheel correspond to 30 teeth of the toothed wheel moved by the screw. On another hand, the twenty revolutions allow 160 teeth of the face wheel to escape, and this makes a like number of revolutions of the wheel of the vehicle, that is to say, 1,600 cubits. Consequently, a single tooth of the preceding wheel indicates $53\frac{1}{3}$ cubits. Thus, for example, when, in starting from the origin of the motion, the toothed wheel will have revolved by 15 teeth, this will indicate 800 cubits,

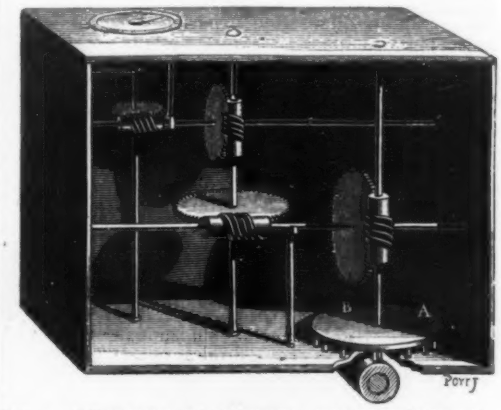


FIG. 1.—HERON'S ODOMETER FOR VEHICLES.

say 2 furlongs. Upon this same wheel we shall therefore write $53\frac{1}{3}$ cubits. Making a similar calculation for the other toothed wheels, we shall write upon each one of them the number that corresponds to it. And, in this way, after we ascertain by how many teeth each has moved forward, we shall know by the same the distance that we have traveled.

Now, in order to be able to determine the distance traveled without having to open the box in order to see the teeth of each wheel, we are going to show how it is possible to estimate the length of the route by means of an index placed upon the external faces. Let us admit that the toothed wheels of which we have spoken are so arranged as not to touch the sides of the box, but that their axles project externally and are squared so as to receive indexes. In this way the wheel, in revolving, will cause its axle with its index to turn, and the latter will describe upon the exterior a circle that we shall divide into a number of parts equal to that of the teeth of the interior wheel. The index should have a length sufficient to describe a circumference greater than that of the wheel, so that such circumference may be divided into parts wider than the interval that separates the teeth. This circle should carry the number already marked upon the interval wheel. By this means we shall see upon the external surface of the box the length of the trip made. Were it impossible to prevent the friction of the wheels against the sides of the box, for one reason or another, it would then be necessary to file them off sufficiently to prevent the apparatus from being impeded in its operation in any way.

Moreover, as some of the toothed wheels are perpendicular to and others parallel with the bottom of the box, so too the circles described by the indexes will be some of them upon the sides of the box and others upon the top. Consequently, it will be necessary to so manage that the side that carries no circle shall serve as a cover, or, in other words, that the box shall be closed laterally.

Another engineer, probably Greeko-Latin, since he expresses distances sometimes in miles and sometimes in stadia, has pointed out an arrangement of a different system for measuring the progress of a ship.

We shall describe this apparatus, which we illustrate in Fig. 2.

Let A B be a screw revolving in its supports. Let us suppose that its thread moves a wheel, △, of 81 teeth, to which is fixed another and parallel wheel, E (a pinion), of 9 teeth. Let us suppose that this pinion gears with another wheel, Z, of 100 teeth, and that to the latter is

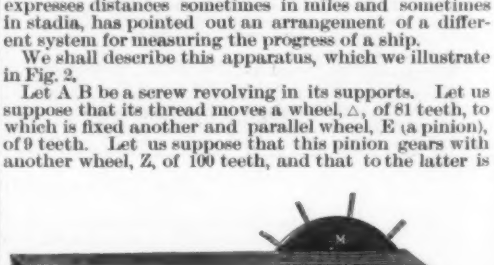


FIG. 2.—ODOMETER FOR VESSELS.

fixed a pinion, H, of 18 teeth. Then let us suppose that this pinion gears with a third wheel, Θ, of 72 teeth, which likewise is provided with a pinion, K, of 18 teeth, and again that this pinion engages with a wheel, Λ, of 100 teeth, and so on; so that finally the last wheel carries an index so arranged as to indicate the number of stadia traveled.

On another hand, let us construct a flywheel, M, whose perimeter is five paces. Let us suppose it perfectly circular and affixed to the side of a vessel in such a way as to have, upon the surface of the water, a velocity equal to that of the vessel. Let us suppose, besides, that, at every revolution of the wheel, M, there advances, if possible, one tooth of △. It is clear that then, at every distance of 100 miles made by the vessel the wheel, △, will make one revolution. So that, if a circle concentric with the wheel, A, is divided in-

to 100 parts, the index fixed to A will, in revolving upon this circle, mark the number of miles made by the number of the degrees.

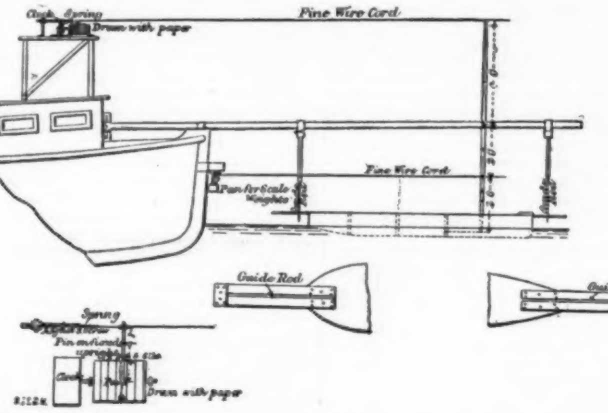
Odometers, like so many other things, have been reinvented several times, notably in 1662 by a member of the Royal Society of London, and in 1724 by Abbot Meynier.—For the foregoing we are indebted to Albert de Rochas' scholarly work Les Origines de la Science et Ses Premières Applications.

EXPERIMENTS WITH SHIP MODELS.

AT the extensive shipyard of the Naval Construction and Armaments Company, Limited, at Barrow-in-Furness, England, some interesting experiments with models have recently been made, and we present a diagram of the arrangement, for which we are indebted to Engineering, as well as for the following particulars.

A new departure in the work of design was made at the establishment when the company were asked to construct torpedo boat destroyers of 27 knots speed, and the system organized by Mr. Adamson is specially interesting in view of its simplicity and the large measure of success that has been attained—the margin of accuracy comes well within the limits of practical success, and this, after all, is as much as can be said of most technical, as distinguished from laboratory experiments. The system is a modification of that introduced by the late Mr. Froude; but the apparatus is inexpensive, and instead of an inclosed tank, the Devonshire Dock is utilized. The experiments were first made at Barrow in the winter of 1893, under the direction of Mr. George Brown, the assistant chief draughtsman, who has charge of the scientific work in the designing department. The data obtained were embodied in the design of the three 27 knot destroyers then built, and were amply confirmed by actual experience with the vessels when on trial. This success induced the builders to make similar experiments with the model of the later 30 knot destroyers.

The model is run with the assistance of a launch, the speed of the launch and of the model bearing a known relation to the speed of the full sized vessel, and the mechanism for ascertaining the resistance is placed on the launch. The method adopted is shown in the diagram. It was, of course, inadvisable to tow the model behind the launch, on account of the disturbance in its wake. A long spar or bowsprit was, therefore, rigged over the bow of the launch, the length of the projection being sufficient to keep the after end of the model about 4 feet in advance of the bow of the launch. The model is guided by rods at each end, these rods being free to swing fore and aft, while rigid in an athwartships direction. The rods hang from the spar into fore and aft guide slots of hard wood, projecting past the ends of the model. The necessity for these will be apparent to any one who has discovered the impossibility of towing a ship or boat in a straight fore and aft line without the help of the rudder or some other means of steering. A model free but for a towline fixed to its extreme fore end will, when towed, swerve to one side or the other indifferently, and will travel along in a half sidelong fashion.



The model is towed at the lower end of a long balanced lever, the connection being a wire link hooked to the lever, and to a bulkhead left in the model when originally hollowed out. The lever, left free to swing round its center in a fore and aft vertical plane, is pivoted at its center on the spar, and its upper end is connected to the recording gear by a fine wire cord, which previous to using is thoroughly stretched. Exactly half way between the center of the lever and its lower end, another wire is connected to the lever and led aft over a pulley on the stern of the vessel. From the aft end of this wire is hung a scale pan to which is attached a permanent weight to keep the wires tight and put a slight initial strain on the spring. This helical spring is introduced into the upper wire, and its extension when the model is towed gives a measure of the resistance of the model. The extensions of the spring are recorded on an exaggerated scale on a paper stretched round a drum driven by clockwork. The markings are made by a small pen attached to one end of a light wooden lever, the other end being fastened to the wire immediately forward of the spring. The clockwork is so arranged as to give about one revolution of the drum in the time taken to pass over the measured distance at full speed. To obtain a scale by which to read the extensions of the spring in pounds resistance, weights of known specific gravity are placed in the scale pan at the stem of the model—2 pounds in the pan being equal in effect on the spring and pen to 1 pound resistance of the model. By marking on the paper the position of the pen with different weights in the pan, a scale of pounds resistance was obtained.

When running, the clock is started, and as soon as the measured distance is reached, the pen is lowered on to the paper on the revolving drum, tracing an oscillating line. The oscillations are, of course, partly due to the natural oscillations of the spring, and partly to the vibration of the launch and the spar due to the beats of the propelling engines of the launch. The mean of the oscillations, obtained by integrating with planimeter, give the resistance of the model at that particular speed. The results are plotted in the form of a curve as resistance in pounds in terms of the speed of the model in feet per second. The spots, owing to the causes mentioned later, do not give a fair curve, but by taking plenty of spots, and running a mean curve through, the error is minimized.

The total resistance, of course, combined two elements—surface friction and wave making—the relations between these two for ship and model following a different law of comparison, and being in different proportions. Froude's experiments give a means of calculating the amount of surface friction resistance for both ship and model, the residue of the model's resistance being wave making, which, for corresponding speeds, varies directly with the displacement, or as the cube of the dimension. Dealing with the two parts separately, the total resistance of the ship is obtained, which, expressed in foot pounds per minute, gives the effective horse power or horse power actually required to drive the vessel at the speed. To this has to be added an allowance for the power lost or otherwise used in driving pumps, overcoming friction, etc., an amount which varies with the type and speed of engine and propellers, but in a case of this kind should not be much more than 40 per cent. of the total indicated horse power.

It is not contended that the results so arrived at are absolutely correct. With comparatively rough gear in an exposed dock such consistent and steady results were not anticipated as are obtained with the elaborate and delicate machinery in use in covered-in experimental tanks. The aim was to furnish in the case of such unprecedentedly fast craft some independent and reliable check on the estimates for power, so as to avoid the risk of serious error. As a matter of fact, the results exceeded all expectations, particularly in view of the difficulties, and especially the fact that the model was run in a large dock in which the water is rarely absolutely smooth—a very slight ripple in the dock being, in proportion to the size of the model, a rough sea. It is, perhaps, unnecessary to remark that the experiments were only made in fine calm weather when the dock was as nearly as possible smooth. Again, the fact that no account is taken of the effect of the screw propellers on the vessel's resistance is in itself a serious drawback; but, as we have said, it gives a good independent check on estimates of power for exceptional speeds, and therein is great advantage. The launch used has a maximum speed of just over 7 knots, which, with a model $\frac{1}{20}$ of the full size—the scale used in the first experiment—corresponds to a speed of 31½ knots for the ship. As it was considered desirable in the case of the faster destroyers to have results up to a speed of about 35 knots, the scale of the new model was made $\frac{1}{24}$ of the full size; running at 7 knots, this corresponds to a speed of 34¼ knots for the ship. Better results would probably have been obtained with a larger model, but the size was restricted by the speed of the launch used for towing the model. The speed of the launch was, for want of a better method, measured by the time taken to pass a known distance, marked on the side of the dock in the usual way by two pairs of posts set square off the course. The engines were set to the desired speed some time before reaching the measured course, and not touched until the run was over, so as to have a constant speed on the run.

FIXING AND WASHING OF PAPER PRINTS.*

By A. HADDON.

THE permanency of a print depends on the thorough removal of salts of silver from the high lights and the subsequent elimination of the fixing agent. The removal of the fixing agent can be easily and most rapidly effected by means of plain water, but the complete removal of the insoluble salts of silver, in the case of albumenized paper, is a task which up to the present has not been accomplished. Hyposulphite of soda will dissolve with ease the insoluble inorganic salts of silver from the paper, but the organic salt, most probably albumenate of silver, is not so easy to dissolve, and, if silver prints are to be made more permanent than they are at present, we must devote our attention to the solution of this difficult problem. The complete removal of the organic salt is not an impossibility, but we must consider the effect of the reagent on the material of which the picture itself is formed.

On August 3, 1893, Mr. Grundy and myself read a paper before the London and Provincial Photographic Association, in which we gave in detail our endeavors to arrive at the cause of the fading of prints on albumenized paper, and also the time necessary for the complete removal of the hyposulphite of soda from such paper by washing in running water.

The method we adopted was briefly this: Albumenized paper was sensitized on a fifty grain nitrate of silver bath, neutral, for three minutes; the paper was then allowed to dry in the dark. When dry it was cut up into pieces measuring 5⅝ by 8¼, i. e., each piece was one-eighth of a sheet. Three sheets were necessary, and each piece from the same sheet was marked so as to distinguish the pieces from the different sheets.

The paper was then washed and fixed just as would have been done had these pieces of paper been prints instead of unprinted paper. The strength of the hypo solution was twenty per cent., and the time of fixation, as usual, fifteen minutes.

In all cases a quarter of a sheet was dealt with, in order to obtain a sufficient quantity of material to work upon, and, in order to obtain a mean result, the two pieces were selected from different sheets.

After the washing was completed, two pieces were set aside to determine the quantity of silver to be removed and the amount of sulphur in the paper after fixation, also two pieces were selected to estimate the silver, soluble and insoluble, and the total sulphur. The remainder of the fixed paper was then transferred to a large vessel filled with water, and into which water was running from a piece of India rubber tubing connected to the water supply. The temperature of the water was 13° C. During the first hour the pieces of paper were constantly turned over by hand in order to prevent them sticking together.

Two pieces were removed at the end of 5, 10, 15, 25, 40, 60, 90, 120 minutes, and 19 hours, and the amounts of sulphur and silver determined

The estimation of the sulphur and silver was carried out as follows:

In each case the two pieces of paper were allowed to drain for five minutes, and then torn up into small pieces and placed in a large beaker with a mixture 100 cubic centimeters of nitric acid, and 200 cubic centimeters of hydrochloric acid (free from sulphur), covered with a clock glass, and heated on a sand bath till the paper was completely destroyed. The solution was then taken down to dryness, and 250 cubic centimeters of pure distilled water and three drops of hydrochloric acid added, and the whole heated to boiling, allowed to cool, and filtered, and the filter paper broken and washed with boiling distilled water. The filtrate was heated to boiling point, and chloride of barium added, which precipitated all the sulphates present as barium sulphate. This was collected on a filter, washed, dried, and weighed in the usual way, and from the weight of sulphate of barium the amount of sulphur present calculated.

The chloride of silver on the original filter paper was dissolved out by means of ammonia, and precipitated with nitric acid, filtered off, and treated as in the usual manner.

The figures obtained were as follows:

	Weight of Sulphur. Grammes.	Weight of Silver. Grammes.
In original paper	0·0050	0·0734
In water adhering to paper	0·000032	——
In paper fixed but not washed	0·2243	0·0086
In paper after 5 minutes' washing	0·0063	0·0051
" " 10 " "	0·0045	0·0035
" " 15 " "	0·0048	0·0037
" " 25 " "	0·0044	0·0037
" " 40 " "	0·0043	0·0033
" " 60 " "	0·0046	0·0036
" " 90 " "	0·0047	0·0038
" " 120 " "	0·0045	0·0040
" " 19 hours' "	0·0047	0·0039

From these figures it will be seen that, after ten minutes' washing in rapidly changing water, as much hypo and silver are eliminated as can be removed in nineteen hours. After ten minutes' washing, the quantities of sulphur and silver become constant.

From the figures given above, it can be easily calculated that about a quarter grain of metallic silver remains in a whole sheet of albumenized paper, and this after the paper has been as thoroughly fixed as is possible using hypo, and after washing so as to remove all that water can dissolve out.

This quantity of silver spread over an area of 17 by 22 inches might at first sight seem to be so small as to have no coloring power when converted into chloride and acted on by light.

Paper fixed and washed as described when brought into contact with sulphureted hydrogen turns brown. When the gas is used it requires time, but when a solution of the gas is employed the action is much more prompt.

The existence of silver in albumenized paper which has not been exposed to light, but has been fixed and washed, can be easily shown by first converting the silver, in whatever form it may exist in the paper, into chloride (by soaking it in chlorine water and washing) and then resensitizing by brushing over the surface a weak solution of nitrate of potash. Such paper, when exposed under a negative, gives a fairly strong print—much stronger, indeed, than would be ascribed to the small quantity of silver present.

In the case of gelatino-chloride of silver paper it is possible to remove the whole of the silver when the paper is fixed in a fairly strong solution of hypo, and the amount of washing, with running water and proper care, was not found to exceed that required in the case of albumenized paper.

It ought not to be astonishing that the whole of the silver from the high lights of pictures on such paper can be removed, as most probably the gelatine is never, during the preparation of the emulsion, in presence of an excess of nitrate of silver, and from this cause no organic salt of silver is formed, as in the case of albumenized paper. Gelatine, however, is a very treacherous compound to deal with, and, if any change in color take place in a print on such paper, it must be due to imperfect fixation, bad washing, a combination of the two, or to the gelatine itself undergoing change.

Long soaking in the case of the gelatine papers is a disadvantage, as the water dissolves out the alum used by the manufacturer to harden the gelatine, and if under these circumstances the prints are squeegeed to glass or ferrotype plates, they invariably stick, and cannot by any means be removed perfect.

Many photographers are under the impression that, in consequence of the greater thickness of the layer of gelatine as compared with albumen, it requires a longer soaking to remove the salt; but this is a mistake, as

* Read before the Photographic Convention of the United Kingdom, July 14, 1896.

gelatine allows the solution of the salts to diffuse through it with equal or even greater facility than in the case of albumen.

The results I have given you thus far are those obtained when the paper has been washed in running water; but this mode of washing cannot be universally employed, as in some cases water may be scarce, and in others it may not be convenient to leave the prints to the tender mercies of the servants in the kitchen, or even in the bath room, and then it becomes necessary to remove the hypo by soaking the prints in water contained in shallow dishes. When this method of washing is adopted, three questions have to be answered before we can say that all the soluble salts have been removed from the prints.

1. What must be the ratio of the volume of water to the area of paper to be washed?

2. How long must the prints be allowed to soak in each quantity of water?

3. How many changes of water must the prints be subjected to?

These questions we have endeavored to answer in a paper contributed to the Photographic Review, June, 1896, and also read before the London and Provincial Photographic Association.

We selected albumenized paper in preference to gelatino-chloride, as the latter is usually so loaded with sulphate of barium that it is exceedingly difficult to obtain clear solutions by filtration through paper, especially when treating the ash of the burnt paper with ammonia; and, from what we now know, it is perfectly clear that what is true of the one kind of paper is equally true for the other as regards time of washing.

We did not attempt to determine the amount of sulphur left in the paper, as it will be remembered that, in the case of albumenized paper, washed in running water, the sulphur and silver disappeared at the same rate, and that, when the quantity of silver became constant, then also did the sulphur, so that the determination of the silver, left at given intervals of washing, was a difficult guide to say how many changes of water, under given conditions, the paper should receive.

The albumenized paper was marked, sensitized, washed, and fixed as already described.

The first thing to be decided before proceeding to the washing of the paper was the ratio of the volume of water to area of paper. For convenience of measurement, we settled on 1 cubic centimeter per square centimeter of paper, i. e., roughly about 1 fluid ounce of water to every 4½ square inches of surface to be washed.

After the prints had been fixed the requisite time, they were plunged and separated from each other as rapidly as possible into the measured quantity of water. After soaking for five minutes with constant movement, two pieces were taken out and dried, the remainder being transferred to another dish with the quantity of water diminished in proportion to the area of paper removed.

This operation was carried on till the last pieces received ten soakings of five minutes each in ten different changes of water.

A portion of each washing water was set aside for testing with permanganate of potash, iodide of starch, and sulphureted hydrogen, dissolved in water.

It was found, by a preliminary experiment, that one drop of each of the solutions of permanganate and iodide of starch produced a distinct coloration in a test tube, filled with water, six inches long, when looked through lengthwise at a sheet of white paper. In order to ascertain when the hypo in the washing water had exactly done its work, such a number of drops of the reagents were added to the water, in similar test tubes, so as to just match the tints in the test tubes filled with plain water and one drop of reagent.

The number of drops required in each case, and the amount of silver left after each washing, will be given in a table presently.

The papers being dry, they were placed in a porcelain dish, and heated till ash free from carbon was left. The ash was then washed several times with boiling distilled water, and then boiled with dilute nitric acid, in order to dissolve out the metallic silver. The contents of the beaker were then filtered and washed, and the ash on the filter paper subjected to the action of strong ammonia, in order to dissolve any silver chloride that might have been formed due to impurities in the nitric acid. This, when filtered, was treated with nitric acid, and added to the previous filtrate; the whole was then heated to the boiling point, and a few drops of hydrochloric acid added to precipitate the silver as chloride. The precipitate was then collected and weighed, and the silver estimated in the ordinary way.

The following table gives the results obtained:

Change of Water.	Silver in Quarter Plate.	Number of Drops of		Sulphureted Hydrogen.
		Permanganate.	Iodide of Starch.	
1	0·0055	more than 10	more than 10	brown color.
2	0·0045	" " 10	" " 10	faint tinge.
3	0·0040	2	3	no color.
4	0·0040	1	1	" "
5	0·0044	1	1	" "
6	0·0042	1	1	" "
7	0·0044	1	1	" "
8	0·0040	1	1	" "
9	0·0043	1	1	" "
10	0·0040	1	1	" "

These results show that, at the end of the third washing, the amount of silver becomes constant, and that farther washing has no effect as regards reducing the quantity of silver left in the paper.

The hypo indicators also point to the same result, that, after the third change of water, no hypo is present to discharge the color of the permanganate or decompose the iodide of starch.

Three soakings in different water seems at first sight insufficient washing to remove the salts, but at the same time we must remember that all that the water has to do is to displace a given volume of the solution of hypo contained in a medium through which diffusion can take place very readily. The silver is already in solution, and it is merely a matter of rate of diffusion. Naturally it takes longer for the last traces to be removed than it does for the bulk of the salts to pass out.

Five minutes ought to be amply sufficient for the salts to diffuse out into the surrounding water; and, if this be so, it becomes a very simple calculation to find how many changes of water the prints must be subjected to in order to reduce the quantity of hypo in a given area of paper to something so very small that it is incapable of producing any deleterious effect on the print.

Hypo eliminators have been recommended at different times, and praised by some and abused by others. If the same amount of trouble be taken, using plain water instead of these salts, I am sure equally good, if not better, results will follow. Any hypo oxidizer is dangerous, in that it is likely, by destroying the solvents, to throw down some silver compound when it would not have been deposited if water only had been used. Fortunately, however, we are generally recommended to give the prints three or four washings before applying the compound, and this is the safeguard, for, if it had been applied at an early stage of the washing, its effect for evil would be very much more marked than has been the case.

The removal of hypo and the silver compounds formed is an easy matter if done with care. I do not mean to say that the mere soaking of paper at the bottom of a dish for fifteen or twenty minutes will remove these salts; the prints must be constantly turned over so as to bring fresh water into contact with them. The two or three hours' washing, as still recommended by several paper makers, is a mistake, especially if the prints are left to take care of themselves. In the case of gelatino-chloride papers even proper washing for that length of time is detrimental to the quality of the gelatine, it tends to remove the alum the maker has purposely added in order to harden it, and if it be removed by long soaking, on attempting to glaze such prints by attaching them to any support, they invariably stick. Give a short washing, and the result is different.

I am certain, if photographers will persist in their old fashioned way of washing prints for six or eight hours, that it would amply repay the water companies, where much printing is done, to supply labor free, to constantly change the prints in the water, and give short washings, thus insuring better results and a less waste of that most valuable natural product H_2O.

BLACK AND SMOKED GLASS.

FINE grades of black glass are made in flint glass, commoner grades in ordinary alkali lime glass. The shade is imparted usually by making a mixture of colors that will neutralize each other well, such as iron, manganese, copper, cobalt, or nickel oxides, when a nice shade is desired, or in case the object is to produce a glass so dark as to be opaque, some cheap material, such as blast furnace slag, iron ores, lava, basalt, etc., is added in excess. A nice light gray or smoked glass is more difficult to make. A mixture of oxides of manganese or nickel, copper and iron is usually employed for this.

The following are a few mixes:

Sand	100
Potash	36
Lime	13
Copper oxide	10
Iron oxide	10
Manganese oxide	10
Cobalt oxide	10

Sand	100
Soda	35
Lime	18
Cullet	70
Cobalt oxide	5
Manganese oxide	10
Ferrous oxide	5
Copper oxide	8

Sand	100
Red lead	82
Potash	38
Niter	8
Ground cullet	40
Cobalt oxide	8
Manganese oxide	8
Ferrous oxide	12
Copper oxide	12

Hyalite glass resembles somewhat, when well made, Wedgwood china. Fine effects can be obtained by cutting and polishing. It is effectively used for vases, slabs, tableware, etc. A cheap mix for hyalite glass is as follows:

Silver slag	20
Blast furnace slag	10
Basalt	10

This is mixed, melted and cooled by dropping it into water. Then it is melted again and cooled the same way. The third time it is mixed with half the weight of bottle glass cullet and melted and worked. A softer glass is made from the following:

Lava	37
Basalt	26
Bottle cullet	100

Another mix highly recommended is to mix with any ordinary batch:

Lava	50
Coal	2
Bone ashes	6

—Diamant.

The Treatment of "Black Eye."—According to the Practitioner, in the treatment of "black eye" there is nothing to compare with the tincture or strong infusion of capsicum mixed with an equal bulk of mucilage and a few drops of glycerine. The bruised surface should be painted with a camel hair pencil, and when dry the operation should be repeated once or twice. Blackening of the bruised tissue may sometimes be prevented if the application be used directly after the injury is inflicted. The same remedy is said to be beneficial in rheumatic sore or stiff neck.

SELECTED FORMULÆ.

Tooth Powders.—The Progres Medical for December 28, 1895, publishes the following formulas which are recommended by M. Metral in the Bulletin General de Therapeutique:

1. Strontium carbonate,	
Flowers of sulphur, each	225 grains.
Essence of rose	6 drops.
2. Strontium carbonate	90 grains.
Flowers of sulphur	195 "
Medicinal soap	55 "
Essence of rose	6 drops.
Mixture of gum arabic,	
Glycerine, each, sufficient quantities.	

The strontium salt, says the writer, assures buccal asepsis by reason of its preservative and antiseptic action. Safranine also gives good results as an antiseptic, and for this reason it should take the place of the ordinary coloring matter in liquid dentifrices. M. Metral employs the following:

Salol	30 grains.
Tannin	30 "
Saccharin	4 "
Spirit of lavender,	
Spirit of melissa, each	225 "
Safranine hydrochloride	0·50 "
Cologne water	2·75 ounces.
Essence of peppermint	12 drops.

The Therapeutische Wochenschrift is cited as attributing the formulas to Thomson:

1. Prepared chalk	2 ounces.
Pulverized camphor	150 grains.
Saccharin	15 "
2. Strontium carbonate	150 "
Calcined magnesia.	

Brewed Non-Excisable Beers.—In his recently issued little handbook Mr. J. Pocock mentions some interesting points regarding the brewing of non-excisable beers. Most recipes published for ginger beer, etc., give one or other of the following proportions of sugar, etc.:

No. 1.

Sugar	8 ounces (5 per cent.)
Yeast	5 drachms.
Water	1 gallon.

Ferment for thirty-six hours, commencing at 70°, but keeping the temperature later on at 60°.

No. 2.

Sugar	12 ounces (7·5 per cent.)
Yeast	1 ounce.
Water	1 gallon.

Let it work for twelve hours, and then bottle.

No. 3.

Sugar	1 pound (10 per cent.)
Yeast	½ ounce.
Water	1 gallon.

Strain as soon as fermentation is brisk, and ferment again slowly for a day or two.

No. 4.

Sugar	1¼ pound (12·5 per cent.)
Yeast	½ ounce.
Water	1 gallon.

Strain and keep at 80° until a brisk fermentation is excited, and ferment slowly for a day or two.

Although the flavoring matters usually added, such as hops and ginger, play an important part in the work of fermentation, they are of no practical importance in regard to the limitation of the alcohol. Nos. 1 and 2 are for brewing beers of the hop beer type, while Nos. 3 and 4 are for the ordinary stone ginger beer. Mr. Pocock had a report from the Somerset House Laboratory upon three samples of beer brewed in accordance with recipes Nos. 1 and 4; the former showed 3·2 per cent. and 3·9 per cent. of proof spirit, and the liquors had a specific gravity of 1000·18 and 1000·64 respectively, while No. 4 yielded 1·7 per cent. of proof spirit; the specific gravity of this last, however, was 1027·96, so that far more spirit would have been found in this sample had it remained in bottle for a few weeks longer. A sample of hop bitters brewed according to No. 1 was found to contain 2·01 per cent. of proof spirit. We mention this note on account of the interesting fact, which some brewers overlook, that a beer may be made to contain a comparatively small proportion of spirit when bottled, but if fermentation is not stopped, then the percentage may go far beyond the legal limit, and bring the retailer into trouble.—Pharmaceutical Journal.

Lime Tablets.—

"A" sugar	20 pounds.
Glucose	5 "
Citric or tartaric acid	5 ounces.

Put the sugar in a clean copper kettle, pour 5 pints of water over it, stir well, and set over a brisk fire. When the sugar is boiling, cover it with a wooden lid, so as to steam down all the grain which may adhere to the side of the pan. Let boil for a while, lift off the lid, add the glucose, and cook to 330° F. After the batch is done, pour on a greased marble slab, fold in the edges, and sieve the acid over the top of the sugar; then sprinkle some lime juice, or oil of lime, over it, and sufficient green vegetable color to give it a bright tint. Fold the batch together and work it with your hands to thoroughly mix the flavor, color, and acid, but do not handle more than necessary, as the sugar should be kept as clear as possible. Lay the mass near the batch warmer; cut off small pieces and run them through the tablet rollers. After they are cold, sift off and put away in tin cans or glass jars. Other fruit tablets are made in the same manner, only changing color and flavor to correspond with name.—Confectioners' Journal.

New Depilatory.—

Alcohol	48 parts.
Iodine	3 "
Collodion	140 "
Ol. turpentine	6 "
Ol. castor	8 "

Mix. Apply every day for three or four days.—Union Medicale.

ENGINEERING NOTES.

Burma's whole system of state railroads has been bought up by a syndicate.

On **the** new Jungfrau Railway no passengers will be accepted until examined medically, and if any of the travelers feel ill they must get out, and they will be afforded medical attendance. This will certainly be a novelty in railway traveling.

The **journey** from London to Paris via Dover and Calais has been accomplished in six hours and twenty-five minutes, reducing the record by one hour and thirty-five minutes—a remarkable diminution. Fourteen minutes were gained between Victoria and Dover. The Straits were crossed in sixty minutes by the steamer Empress.

An **exhibition** of what happens when trains collide was given at Buckeye Park, Ohio, May 30. Two condemned locomotives and three cars were run against each other at an alleged speed of fifty miles an hour. The result was what might have been expected, the only curious thing being that 18,000 people are said to have paid to see it.

The **British** Journal of Photography says that acetylene is being tried on some of the tram cars in Paris, and with promising success. The generator, containing the calcium carbide and water, weighs under 30 lb., and is placed beneath the steps of the vehicle, and it contains sufficient material for generating 35 ft. of gas. As the lighting power of acetylene gas is something like fifteen times that of coal gas, the cost is stated to be less than illuminating the cars by petroleum.

Among the subjects as to which communications are invited by the Liege Association of Engineers, in competition for prizes, are the following: The mechanical methods employed, and to be employed, for bringing down coal, £20; progress in underground haulage, £28; the best methods for the generation of combustible gas, £20; the application of liquid or gaseous fuel to the generation of steam, £40; the external and analytical characteristics for distinguishing the various classes of coal in one of the Belgian basins, and their industrial applications, £20; a method for practically suppressing the danger of blasting in fiery mines, with evidence in support of its superiority over the best methods now known, £40; and the best means for utilizing in coke making such non-bituminous coals as have not hitherto been used for such purposes, £40.

The Eastern Railway of France has given acetylene a trial in lighting a first-class coach of a Paris-Metz express, says the Railway Age. The compression of the acetylene was accomplished in a reservoir of similar construction as that of the gas tanks used regularly on this line. It was burned in a small special Manchester burner with an extremely small special slit, in order to obtain the most perfect combustion. The results of the tests, as stated by the Swiss Builders' Gazette, were as follows: "Twelve liters of acetylene gas were consumed to produce a lighting effect of two carcels, or 18·04 normal candles per hour. If the ton of calcium carbide is valued at 550 francs ($107.15), the average yield of 1 kilogramme is calculated at 300 liters of acetylene gas, the cost of lighting would amount to exactly 2 centimes, or two-fifths of a cent per burner, or 1 centime per carcel hour. Calcium carbide is being sold by the factory at Neuhausen for 400 francs, or $76.30, but its actual yield in gas would be hardly more than 280 liters per kilogramme. If the cost of calcic carbide could be reduced by one-third or one-half, which is quite probable, the use of acetylene gas would offer, in regard to economy, considerable advantages, if compared with coal gas."

In order to determine the highest possible speed that may be attained on railways, trial runs were lately made between Berlin and Lubbenau, on the Berlin and Gorlitz line, states the Rheinische Westphalische Zeitung, and for these runs a special express engine of new design with four cylinders and driving wheels of 2 meters (6 ft. 6 in.) diameter has been constructed, thus giving the engine a much greater height above the rails than usual. For these runs the composition of the trains was very various, amounting sometimes to 100 axles. With a train of 30 axles the highest performance, viz., 106 kilometers (65¾ miles) per hour was recorded, being 20 kilometers (12 miles) more than the highest speed hitherto attained by the quickest German lightning train (Blitzzuge), viz., the Berlin-Hamburg D-Zug, which runs through a distance of 286 kilometers (177⅝ miles) in 3½ hours, while the speed of ordinary German expresses is only 70 kilometers (43½ miles) per hour. Not any of the runs have hitherto been accompanied by accident, although the trains have run past all the intermediate stations without slackening speed. The portions of lines chosen for these runs have been tolerably horizontal over their whole length, and have very few curves.

The extent and peculiarity of some of the mining methods pursued in the famous Johannesburg gold region, in South Africa, are noteworthy for the mechanical ingenuity displayed. The Journal, published at that place, describes the slimes plant of Crown Reef as comprising six circular iron vats, 32 ft. in diameter and 10 ft. deep, a concrete floor sloping from the circumference to the center. This set of vats is just above a cyanide shed, and a few feet lower are two 20 ft. receiving vats for the solutions from the leaching vats, prior to passing to the precipitation boxes. Below the shed is the big solution tank, 40 ft. in diameter and with a capacity of about 70,000 gallons; the quantity of solution must, of course, be very large, and the precipitation boxes, six in number and built of brick, are arranged, as is desirable in the case of weak solutions, for the electrical precipitation process, with sheets of iron and lead. The complete pulp treatment plant comprises the classifiers, with five concentrate vats, the treatment of sands, and the treatment of the slimes; the concentrates are received in two vats for a first treatment, and are then transferred to the other three vats for the remainder of the process. The sand treatment remains as usual, but the overflow from the vat passes to a series of separators, separated, from the bottom of which further sands are obtained and removed by trucks. From the separators the overflow passes on by launder, in which a precipitating lime solution mingles with the slimes to a series of separators. The slime settled here by the lime is pumped as a sludge to the leaching vats.

ELECTRICAL NOTES.

It is said that Chicago now has 760 miles of electric railroad plant.

The Pilots' Association, of New York, has just completed plans for a new electric lighted steam pilot boat.

Electron is the name of a new electrical paper published in Madrid. It is devoted to the interests of the Spanish telegraphic service.

There were two hundred delegates present at the International Congress at Geneva, which opened on August 4. M. Turrettini presided. Among the subjects discussed was the question of the transmission of power over long distances, and practical exhibitions of its transmission were made at the exposition.

September 9 marked the completion of the fiftieth anniversary of the introduction of telegraphy into Belgium, and the postal department celebrated the event in a suitable fashion. In 1851 the total number of messages transmitted was 19,600, and the receipts $17,600. For the year 1894 the respective figures show a total of over 8,300,000 messages and $700,000.

A novel feature of the electric lighting service at Niagara Falls is the practice adopted by the local company of purchasing current at wholesale and selling it at retail. The idea might be elaborated and developed, says the Western Electrician, but it is safe to say that there are few, if any, points in this country, outside of Niagara Falls, where such a project could be successfully conducted.

The new highway bridge across the Connecticut River connecting Middletown with Portland, Conn., is now swung by electricity, says the Electrical Engineer. The electrical equipment consists of four G. E. 800 horse power motors. Two of these are connected with the swinging mechanism, one working and the other being held in reserve. Of the other two, one is located under each end of the turning span, to raise it from the fixed piers before the third motor begins to swing it. The bridge span is 450 feet long, the longest single span highway bridge in the world. Previous to the installation of this electrical equipment by the General Electric Company, fifteen men were required to start the bridge and eight men to swing it.

The German Hygienic Association is offering, says the Iron Age, a prize of twelve hundred dollars for an essay on the efficiency of electric heaters. The terms are as follows: The heat given out in heating installations by heaters in their various forms and modes of use is to be ascertained. The investigations are to be described in detail in respect to the arrangement of the heaters, the nature of the heating agents and the observations made; and they are to be illustrated by drawings. The heating values obtained are to be stated in units of heat given off per hour per unit of surface. In the case of heat given out to air, the investigations must be conducted with currents of air at speeds as different as possible. The heaters are to be described in detail as regards form and measurement, and the relation of their heating efficiency to their weight is also to be ascertained.

Askenasy's improved process is to purify sulphuric acid in the following manner, says the Trades Journals Review. The crude acid is electrolyzed at ordinary temperature by currents of six volts and one or two amperes per square decimeter, by means of lead electrodes; the liquid is first kept quiet, and then agitated during electrolysis. The ozone generated at the positive pole is to destroy all organic matter, so that the acid becomes colorless. On the other electrode sulphur is liberated in fine clouds, which reduces any nitrogen compounds present. Most of the metals are to be precipitated as sulphates; hydrochloric acid is to be destroyed by the ozone, and the chlorine to fall out as lead chloride. No diaphragms are required. The temperature may profitably rise toward the end of the treatment, so that the various sulphur compounds precipitated agglomerate. It is also proposed to dilute after electrolysis with water, when sulphureted hydrogen will be liberated. Traces of lead would not be removed, but this would be of little importance for the manufacture of accumulators, which seems particularly to be aimed at.

Captain Charollois has communicated to the French Society of Civil Engineers some interesting experiments he has made in the direction of military telephones. He has been investigating the distance at which conversation is possible if a bare wire is laid direct on the ground with earth return. In spite of the leakage to earth along such a line, he has found that speech can be transmitted perfectly over a line 15½ miles long. The ordinary call bells cannot, however, be used, and hence Capt. Charollois has devised a magneto call to act on the diaphragm of the receiver. We consider, says the English Electrical Engineer, the experiment most interesting as showing how bad a circuit must be before a telephone will refuse to act, but not as a guide to general practice in such work. We remember an instance some years ago in which a telephone erected as an attraction at a local flower show worked comparatively well although a portion of the circuit was completed through the canvas of a tent. The wire had broken, and the bare ends, held a few inches apart by the insulation, rested against the canvas of the tent inside which the telephone was working.

The first electric locomotive of any considerable size built in this country and the first practical electrical locomotive in the world, exhibited by the General Electric Company at the Chicago Exposition, 1893, having a rated drawbar pull of 7,000 pounds, has been purchased by the Manufacturers' Street Railway Company, of New Haven, Conn., says the Colliery Engineer. It is equipped with air brake and is being prepared for shipment from the Schenectady works within a very few weeks. Its total weight is thirty tons, and it will be utilized to haul freight cars from the junction of the New York & New Haven Railway at Cedar Hill, which is about one mile from the New Haven passenger depot, to the works of the Bigelow Company, manufacturers of boilers, the National Pipe Bending Company, the Quinnipiac Brewing Company, the New Haven Rolling Mills and other manufacturing establishments located along the water front at some distance from the freight yards of the Consolidated road.

MISCELLANEOUS NOTES.

The cultivation of the cassava plant has been begun in the United States. It is a shrub from 6 to 8 ft. tall, and bears large tubers underground. These are first heated to drive off the poisonous hydrocyanic acid, and they are then made into tapioca and dextrine. It is said that the latter can be more easily manufactured from this plant than from corn.

A recent search of the patent records disclosed that Robert Bayley received a patent May 15, 1812, for "a new and useful improvement" called the Fair Dealer or the Chartæ Lusodiæ. The letters patent were under the hand of James Madison, President, by James Monroe, Secretary of State, and were executed by William Pinckney, as Attorney-General. In the schedule which was attached to the patent the ordinary faro deal box is described perfectly.

The idea of copper toed shoes was patented January 5, 1858, by a Maine genius, who made $100,000 out of it. Another similar invention which made a great deal of money was the metal button fastener for shoes, invented and introduced by Heaton, of Providence. At the time it was considered a fine invention, for the old sewed button was continually coming off. It has gradually grown in popularity since its introduction in 1869, until now very few shoes with buttons are manufactured without the Heaton improvements and appliance.

At Grosny, on the north slope of the Caucasus, naphtha has been found in very large quantities, some of the borings yielding as much oil as the richest Baku wells. One gives 13,000 tons of naphtha in twenty-four hours. A pipe line is being constructed to the nearest railway station on the Wladikowkos Railroad, eight and a half miles away. The wells are nearly all in the hands of Tiflis and Baku capitalists, among them the Nobels. On the Black Sea slope of the mountains large deposits of manganese have been found at Egeri in the government of Kutais, silver-bearing lead ore in in the Szuchum district, and iron and titanium at Nowla and Nadirima Darassi.

A novel application from the Hot Water Supply Syndicate, Limited, was before the lighting committee of the Liverpool corporation lately. They asked for permission to erect experimentally three lamp columns and fittings for a period of three months for supplying hot water to the public by means of a coin freed machine. The method proposes the utilization of the heat given off by the gas burnt in the street lamps, and the hot water is charged for at the rate of a ½d. per gallon. The syndicate claim that, wherever the system has been introduced, it has been a boon to the working classes. The committee acceded to the application, and left all the arrangements for the experiment in the care of the gas inspector and superintendent of street lighting.

According to a correspondent of the London Times, many flowers are now brought into market "out of season" by freezing the bulbs, or retarding their growth by placing them in an icehouse. He asserts that the method is a secret; but the simple fact is that all sorts of practices are adopted by growers to put goods on the market when there is a scarcity, and much skill and science are required to attain success. In the case of the lily of the valley (Convallaria), it may be of interest to point out that the bud (crown) in which are inclosed both leaves and flower in embryo, is fully formed during the autumn, or some six months before it flowers in the ordinary course of events. When forced in the old-fashioned manner only about 50 per cent. of the buds can be got to flower early in January, and perhaps only about two-thirds of that proportion before Christmas. By the method of retarding, fine flowers, well developed leaves, and an average of 95 per cent. may be had from the end of summer up to Christmas, while a period of three weeks is sufficient for the development of the flowers.

The longest and quickest balloon voyage ever made was that of Wise and La Mountain in 1859 in a spherical balloon propelled by the wind, says the American Engineer. They sailed from St. Louis, Mo., on the evening of July 1, and landed the following afternoon at Henderson, Jefferson County, N. Y., having traveled 1,150 miles in 19 hours and 50 minutes, a speed of more than 57 miles an hour. The highest balloon ascent ever made was by Dr. A. Berson, near Kiel, in Germany, December 4, 1894, in a spherical balloon inflated with 70,600 cubic feet of hydrogen and supporting a guide rope 650 feet long. The ascension was begun at 10:28 A. M. and the balloon reached a height of 6,500 feet in the first fifteen minutes, a vertical velocity of about 433⅓ feet per minute, after which it ascended more slowly, and finally attained its highest altitude, 30,000 feet, or 5 $\frac{7}{10}$ miles. The temperature increased at first, rising to 41° Fah., at an altitude of 4,900 feet; after which it began falling, and at 16,000 feet was at zero. After 30,000 feet, the greatest altitude, it had fallen to 54° below zero, and the barometric pressure to 9⅛ inches, less than one-third the average pressure at the earth's surface; and the air was very dry.

An account of the new fireproof paper prepared by L. Frobeen, of Berlin, shows the production of a valuable article for industrial and other purposes. Ninety-five parts of asbestos fiber of the best quality are washed in a solution of permanganate of calcium and then treated with sulphuric acid, the fiber being thus bleached. After treating the fiber in this manner, five parts of ground wood pulp are added, and the entire mass placed in the agitating box, with an addition of some lime water and borax. After being thoroughly mixed the material is pumped into a regulating box and allowed to flow out of a gate into an endless wire cloth, where it enters the usual paper making machinery. Paper produced in this way, it is reported, will resist even the direct influence of a flame, and may be placed in a white heat with impunity. Ordinary paper may be made fireproof by treating it with a fluid consisting of thirty-three parts manganate of chloride, twenty parts orthophosphoric acid, twelve parts carbonate of magnesia, ten parts boric acid, and twenty-five parts chloride of ammonia in one quart of water; this solution is applied several times, and paper saturated with it will resist great heat and the direct influence of flame for some time.

[Continued from SUPPLEMENT, No. 1080, page 17268.]

THE ART OF BRONZE CASTING IN EUROPE.*

By GEORGE SIMONDS.

THE most important casting ever made in France, or perhaps in any other country, was that of the statue of Louis XIV, by Girardon, and cast in bronze by the celebrated founder, Jean Baltazar Keller, in 1699. M. Boffrand, the eminent architect, was instructed to take notes and to make drawings of the entire process, and these form a most valuable addition to the literature of bronze casting.

I propose now to describe the method of procedure which proved entirely successful for the casting of this great work, alluding from time to time, as may be convenient, to works by other artists who may have used other means to the same end.

This statue, of which I show you a lantern slide, exists no longer. It was destroyed, with many others, in the French revolution. It was of great size, measuring 21 French feet, or about 7 meters in height. The statue was modeled in plaster, on the site where it was to be cast, in a temporary studio erected for that purpose. When the work of modeling was completed, the entire statue, horse and rider, was piece moulded in plaster. This was not, however, an ordinary piece mould, but rather an erection of regular shaped blocks of plaster of such size and weight as to be easily lifted by hand. This very complicated mould was regularly built up in courses like masonry, each piece being keyed to its neighbors, until the entire statue was built in. The blocks, which were all carefully numbered and countermarked, were then removed one by one, and each lined with wax. This was first painted on with a brush, which, in my opinion, was a mistake; and when a very thin layer was thus obtained it was backed up by sheets of wax, rolled out to the required thickness, which varied according to the position, some of the parts being very thick indeed. The next point was the arrangement of the iron frame for the support of the core. This was a very complicated construction, and was all fitted together with clamps, so that it could be taken to pieces and removed, together with the core, through an opening or manhole on the back of the horse. The irons of the legs, however, were intended to remain inside. The framework was erected above a series of flues or fireplaces, of which the use will be shown hereafter. An iron grating, which was to form the base of the waste mould, was laid over these flues, and upon this the piece mould was erected, course by course; and the iron framing was built up, and the core was being made at the same time, so that, when the plaster mould was entirely built up and restored to its proper position, there was on the outside, first the plaster mould, next to that a lining of wax representing the bronze, and within that again the core, which enveloped the iron framing by which it was to be supported.

There are many ways of making a core, but they may be divided in two classes, viz., beaten cores, that is to say, such as are composed of some material that can be beaten or rammed into a cavity, from which it receives the required form, and cast cores, or such as are poured into the cavity in a fluid state, and are then allowed to set and solidify.

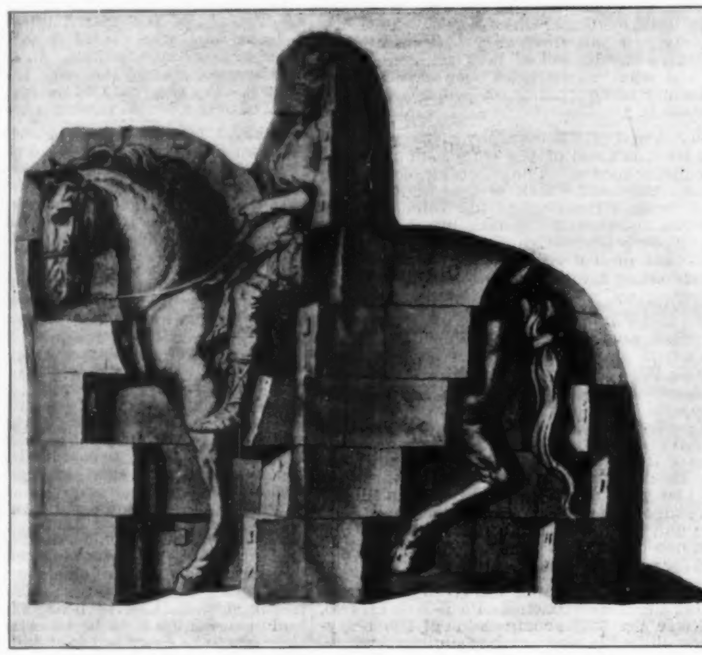
Beaten cores are the safest, but cast cores are the most convenient to make. In this case both kinds were used. The legs of the horse that touched the ground were to be cast solid a considerable way up, and being full of wax and irons, needed no coring. The tail, part of the neck and head of the horse, the raised legs and the body, head, and arms of the king were cast cores; but for the legs of the king and the body of the horse a beaten core was used, which was composed of two parts of loam and one part of horse dung mixed with cow hair and beaten well together with iron rods, and sufficiently moist to be fairly plastic.

The workmen, passing their hands into the body of the piece mould between the irons of the frame, plastered the wax shell with a layer of this loam about one-half inch thick. This was carefully dried, and other layers were added, until the lining covered in all the irons of the framing, it being then about six inches thick. Bricks of the same material that had been prepared beforehand and well dried, were now used to increase the thickness, using the same loam in a more fluid state as mortar, until the body of the horse was fitted with a sort of vault, open only at the manhole in the horse's back. In this vault braziers of charcoal were kept alight until it was perfectly dry. Previously, however, the body, head, and arms of the king, as well as the raised legs, head, neck, and tail of the horse, had been cored by pouring into them a mixture of one part of brickdust and two parts plaster in a liquid state.

Through the body of the king three small chimneys had been formed leading from the body of the horse to the open air above. This is the first record I have ever found of a lantern and core vents, and yet, strange to say, it was not intended to be used as such, for, as the core dried, fresh layers were added, and the whole was finally filled up to a solid mass—a very great mistake in my opinion.

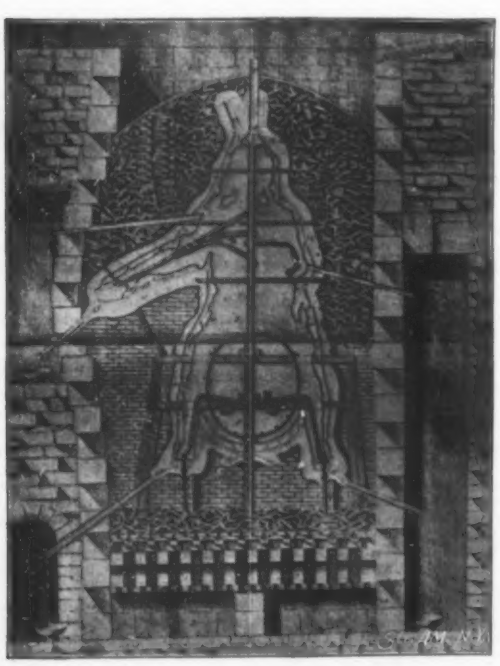
It would be tedious to enter into every detail concerning the construction of the core. I have merely stated the broad fact. The next operation was the removal of the plaster mould together with the wax, so as to expose the core to view. The latter was then examined to detect any cracks or other imperfections, and after these had been remedied, the lower parts of the core were further secured by a network of iron

EQUESTRIAN STATUE OF LOUIS XIV, ERECTED IN PARIS, 1699.

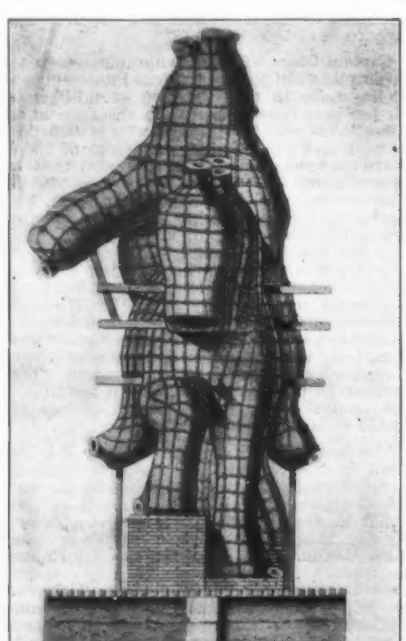


PLASTER MODEL OF STATUE OF LOUIS XIV, PARTIALLY ENVELOPED IN PLASTER MOULD, FORMED IN SECTIONS, FOR THE PRODUCTION OF THE WAX MODEL.

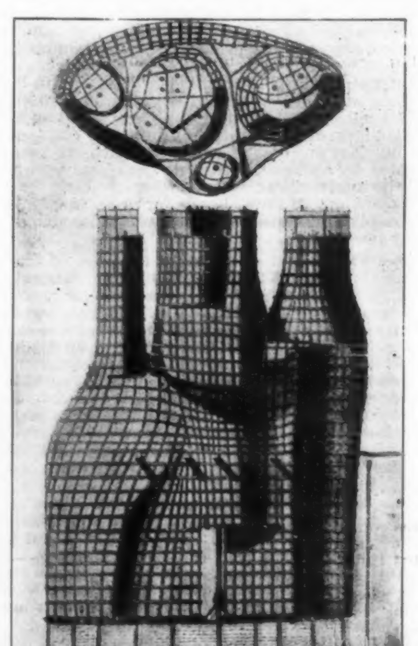
* Lecture before the Society of Arts, from the Journal of the Society.



SECTION OF KILN, MOULD, AND WAX MODEL OF STATUE OF LOUIS XIV, SHOWING THE SPOUTS PROVIDED FOR DRAWING OFF THE MELTED WAX.



FRONT VIEW OF MOULD, WITH IRON BANDS, FOR CASTING THE BRONZE STATUE OF LOUIS XIV.



SIDE VIEW OF MOULD, BOUND WITH IRON BANDS, FOR CASTING STATUE OF LOUIS XIV. ALSO TOP VIEW OF SAME SHOWING THE JETS AND VENTS.

wire, and the wax was then piece by piece replaced in position on the core, to which it was secured by copper tacks, whose heads were buried in the thickness of the wax, and their points driven into the body of the core. When all the pieces of wax had been thus fixed in their proper places, the next thing was to retouch the wax. This must have been a very troublesome job, owing to the method adopted for covering the core; indeed, we are told that it took M. Girardon a whole year to repair. The wax now being retouched, and the entire statue being absolutely finished, the next process was the distribution of the jets, vents, and spouts or drains.

For the benefit of those who have no knowledge of these things, I may as well say that jets, also called runners, are the pipes by which the molten bronze enters the mould and is conducted to its remotest parts. Vents are air pipes leading from the cavity of the mould to the outer air; their function is to permit a free and rapid exit to the air and gases which would, without such exit, impede the free flow of the metal, and in all probability burst the mould. The spouts, or drains as they are called, are also pipes leading from the interior of the mould to the open air. Their function is to carry off the wax as fast as it is melted inside the mould, as if no exit were provided it would, as the heat increased, boil inside the mould, which would destroy its surface and yield a very bad casting. These pipes are merely sticks of wax of varying thickness, according to the requirements of the case, and they are attached to the surface of the wax model by soldering them in place with a hot iron.

There are two opposite principles employed for the arrangement of jets and vents, known as the ascending and the descending principles.

The oldest and commonest principle is the descending, which has many disadvantages, and very little to be said in its favor. It consists in pouring the metal directly into the mould through one or many jets which distribute it to all parts of the mould. It enters the mould from above, and it is claimed that the mould is most quickly filled by this plan.

The other, or ascending principle, has, in my opinion, many advantages. On this principle the jets are so arranged that the metal enters the mould from its lowest point, having descended through runners from above the head of the statue, and rises, on the principle that fluids will find their own level, forcing air, gases, and everything else in front of it until the mould is full. This, no doubt, is the slower plan, since the metal has just twice the distance to flow, but it causes, in my opinion, far less disturbance inside the mould and does not necessitate so many jets and vents.

One of the bugbears of an inexperienced founder is the fear that he will not be able to get his mould filled before the metal is too cold to run or take a sharp impression, and yet, as a matter of fact, more bad castings result from too much heat than from too little. An inexperienced hand is always ready to attribute a mishap to the evolving of the metal inside the mould. Probably his mould did not fill because he had not vented it properly and an airlock was the result; or if the casting is not sharp, it is probable that he has either burned his alloy or that his mould was bad. It is not, in all probability, the result of casting cool.

However, MM. Girardon and Keller decided on adopting the old-fashioned descending process, and placed their jets and vents accordingly, the jets all pointing downward and the vents upward; the spouts of course led downward. When all this was completed the next operation was the construction of the mould itself, together with the walls of the so-called pit, in which it was to be cast, not to forget the furnace to melt the metal.

The soil was so damp in Girardon's atelier that it was considered unwise to dig a pit for casting, as is the usual custom; so the plan adopted, and I believe for the first time, although it has often been done since, was to build a strong wall all around the mould and conduct the whole operation above the floor level of the studio. This wall would rise to a height of 3 or 4 ft. above the top of the mould, and the mouth of the furnace would have to be a little higher than that. The furnace, therefore, in this case will have been about 30 ft. above the ground level.

The construction of the mould was as follows: Three parts loam of Chatillon, two parts powdered crucibles, one part horse dung. This mixture was mixed with white of egg, and ground on a stone until it was of the smoothness and consistency of oil paint, when with soft brushes a first and very thin coat was given over the entire surface of the wax, jets and vents included. When this first coat was entirely dry a second was laid on in the same manner and also allowed to dry, and so in this way 24 coats were given and dried; after this the same mixture was beaten up with cow hair and other layers added, until a thickness of about 2 in. had been reached. This required about 40 coats.

As the mould could no longer be trusted to support itself, a sort of net made of hoop iron was placed under the horse's belly and attached above to the irons that supported the core; a like bandage was put round the body of the king, and indeed wherever it seemed advisable to strengthen the mould. After this fresh layers of loam were added to the mould, until it had received about 150 in all, and was about 8 in. thick, or rather more.

After the mould had been brought to this state, it was entirely enveloped in a lattice work of bands of iron, shaped to the mould, and secured to the grating on which the latter rested. This lattice work was again covered with loam, and in the case of the legs and tail of the horse a second lattice of iron was added, and covered with loam and terra cotta tiles, in order that it might be better protected from the fire. The mould was now about 10 in. thick at the base, and 7 or 8 in. at the top. The next operation was melting out the wax, and firing or cooking the mould. This was a matter of very great difficulty owing to the immense size of the mould, the largest in fact of which we have any historical record.

The following was the plan adopted: A kiln, which the French call le mur de recuit, was built of fire brick around the mould, rising from the flues which I have already mentioned as being below the statue. This kiln was shaped as far as possible to the form of the exterior of the mould, from which it was distant about 18 in., this being considered sufficient for the fire space. As the kiln was built up, it was filled above the flues with bricks laid in such a manner that there was a space of a couple of inches between each, and others laid above so as to form a sort of open work to allow free passage to the flames. After three courses of brick had been laid in this manner, the space between the mould and the kiln was filled up with broken pieces of brick thrown in loosely so as to leave ventilation for the fire. When the kiln had been carried above the level of the top of the mould and filled as described with broken bricks, it was covered in at the top with a layer of clay about 3 in. thick, in which, however, several small chimneys had been made, without which the kiln would not have been workable.

The fire was now started in three flues on each side, and after 29 hours two more were started, and so on with others, until they were all in work. This firing was with charcoal, and was continued for nine days and nights, after which time the wax, which had begun to come away after the second day, ceased to flow. Of 5,688 lb. of wax which were used for this statue, 2,805 lb. were drawn, so that there remained absorbed by the mould 2,765 lb. to be evaporated and burned off before the casting could be made.

To the charcoal fires a few billets of wood were now added, and the heat gradually raised for the space of eight days more, after which time wood only was used, and the fires were well maintained for seven days. Then the whole interior of the kiln being at a full red heat, the flues were closed, and the mould was left to cool for eight days, after which time it was sufficiently cool to permit the kiln to be taken down.

This account gives us nine days for drawing the wax, eight days for raising the fire, and seven days more to bring the kiln and its contents to the proper heat, and another eight days for the mould to cook after the kiln had been closed. In all 32 days, and none too much when we remember the size of the casting; and here I wish to say that firing the moulds is the one great difficulty in waste wax casting. You cannot fire too slowly. The mould and the core, to its very center, should be brought to a good cherry red, but no more; neither should the outside be hotter than the inside. In order to arrive at this result, a gentle fire long continued is needed. A strong, fierce fire only injures and destroys the mould—cracking, tearing, and warping it in every direction; over-firing is the cause of as many, if not more, failures than under-firing; and no fuel is worse to use than coke, on account of the great heat, and also of the sulphur it contains. A fire of soft charcoal, or of wood, is the best and safest.

The mould being now properly cooked, the next thing was to remove the kiln, and everything else, and clear out the pit, so that it contained nothing but the mould. The spouts from which the wax has been drawn were now carefully closed with loam, and the earthing up was proceeded with. The flues, which were directly underneath the mould, were filled up solidly with masonry, and the pit filled in with earth—thrown in to a depth of about 6 in., and well rammed down in every part before another layer was added; and so on until the highest part of the mould was reached. A small quantity of plaster was sifted among the earth thus used, in order that it might take up any dampness and prevent it from affecting the mould.

The next thing was the construction of the basin, or dam, to contain the metal when released from the furnace. This was made of an oblong shape, of beaten loam, the sides being bricked and plastered with loam. From the mouth of the furnace a trench led with a gentle fall into the dam, and from the bottom of the dam proceeded the three principal jets. The mouths of these three jets were funnel-shaped, and were stoppered with carefully fitted plugs at the end of long iron rods, so arranged that, by means of a lever, they could be simultaneously withdrawn at a given signal.

Some time previous to the completion of these last operations the furnace was started, with a charge of 83,752 lb. of metal, being part old cannon, part ingots of red gun metal, part yellow brass, and about 2,000 lb. of fine Cornish tin, besides a mass of old metal that had been used in the arsenal many years before. The fusion of this large charge took 40 hours in this furnace—of which I am pleased to be able to show you some illustrations—after which it was tapped and the entire charge allowed to flow into the dam. The plugs having been withdrawn by means of the lever, the bronze went down quite quietly into the mould, rising in all the vents up to the level of the flooring, a sure sign of a successful casting. The weight of metal taken up in the statue, and its jets and vents, was about 60,000 lb., the remainder was left in the dams. After four days the work of digging out the pit was begun, and the statue was found to be quite perfect. There only remained now to cut off the jets and vents, and to chase over the places where they joined the statue; also to remove the core, and, as far as possible, the iron also, through the manhole at the back and the other smaller apertures that had been provided for that purpose. To close these holes, pieces had been made of wax, carefully fitted and then removed, and placed among the jets in such a manner that they should be cast at the same time as the rest of the work; after which repairs, the statue only required to receive a patina, and was ready for use.

Such, then, is the history of the greatest piece of bronze casting of which we have any record in Europe, for although there are several other bronze statues that far exceed this in height, and indeed rival the colossi that were erected by the ancients, yet these were all cast in sections and fitted afterward.

There is, I believe, no record extant of the casting of Le Sueur's fine statue of Charles I, which is a pity, for it would be very interesting to know if it is, as I suspect, a wax casting.

Chantrey, I believe, used to cast his own statues, and I have been assured that he used to cast them in piece moulds made of plaster and brick dust in equal proportions. I know that this method has been employed by sculptors, but it is more in the nature of a makeshift than a process to be recommended, since a good loam piece mould will be more likely to give good results.

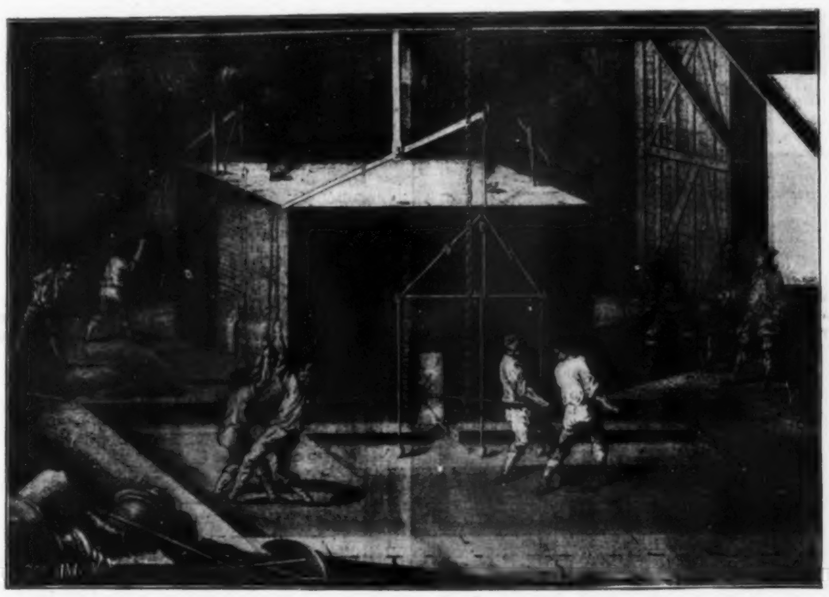
When piece moulding for bronze with plaster brickdust, the mould should be thicknessed up with sheets of tallow or dough rolled to the required thickness, and the core irons having been prepared and placed in position, the core, also of plaster mixed with brickdust, must be poured in and allowed to set. After this the mould must be taken to pieces, and the core removed and thoroughly dried and baked, as must also be the various pieces of the mould. They do not, however, require the same degree of heat as in the wax process. After they have been well baked they must be put together, buried in the earth, and cast as soon as possible. The jets and vents are cut in the material of the mould, in the same way as in the ordinary loam piece moulding.

Among other equestrian statues cast by the wax process, I may mention Louis XV, by Bouchardon, and the celebrated statue of Peter the Great, by Falconet. This last was cast by the sculptor himself, without the aid of a professional founder, and under very great difficulties. This casting is remarkable for being, in the forepart, where lightness was most essential, perhaps the thinnest casting, for its size, in existence. In our own day many fine equestrian statues have been produced in England and elsewhere. Marochetti, I believe, was the last sculptor in England who did his own casting; but I do not know if his methods had any particular interest.

Foley's statues, such as this of General Outram, were all cast in pieces, by the usual loam process, which seems to me, when properly and skillfully carried out, to be sufficient for the purpose.

In this survey of bronze casting in Europe, I have been obliged to omit all mention of much admirable work that has been done in Germany, and in Holland and Belgium, in which last country I got my first lessons in bronze casting, in the studio and foundry of the Chevalier Louis Jéhotte, at Brussels, when I assisted him in modeling and casting the monument of Charlemagne, afterward erected in Liège. This was entirely cut to pieces and cast by the loam process. In Italy they still, in spite of the great cost, keep to the wax process for almost all their public monuments, of whatever size; and I am pleased to show you one that was cast entirely at one pouring, about 20 years ago, by Papi, of Florence, for the sculptor Balzico.

I do not recommend the establishment of large foundries in England for waste wax casting. It is essentially a process that should be used for the production of small, rather than large works; and although Papi cast one of my own works, of colossal size, by this process, I do not think that, as a rule, the game is worth the candle; and I should always employ the piece mould, as being much cheaper and quite as successful. For work up to life size, however, and especially for



TAPPING THE FURNACE FOR THE CASTING OF THE STATUE OF LOUIS XIV, IN THE STUDIO OF M. GIRARDON.

smaller work, where the touch of the artist is of great importance, I should always use the waste wax process.

There is all the difference between a statuette cast from the wax by an artist and the same thing cast in a piece mould in the ordinary way that there is between an original painting and a chromolithograph. The one may be worth more than its weight in gold, the other is hardly worth more than its weight as old brass. On the other hand, it is not the wax process alone that gives value to the work; the design may be admirable, and the artist among the greatest; but if he allows inferior workmen in a foundry to retouch the waxes and repair and chase up unsuccessful castings, then the work ceases to have artistic value, and is no longer an original autograph work, but simply a commercial copy.

It will be an excellent day for English sculpture, and I think that day is not far distant, when the public will insist on autograph work, in small bronzes at least. These may easily be cast with few appliances and in a very small studio. This is a bronze from the wax sketch of my marble statue of the Queen, which I cast in a corner of my own studio. It is left exactly as it came from the mould, and has not even received a patina; only the jets and vents were removed. I merely mention this to show that it may easily be done, and I hope the time may soon come when artists will again take their proper part in the advancement of bronze casting in Europe.

LIGHTNING ARRESTERS.*

By W. R. GARTON.

THE lightning arrester, pure and simple, is nothing more than a convenient path or outlet from the condenser or charged body to a point of lower or no potential. By this we mean that a certain body has by contact or communication with a statically charged body, which may be air, wire or what not, become charged with the influence predominating the adjacent body, or, in other words, the originally charged body, which, in this instance, is the atmosphere, has given off to the conductor, which it surrounds, the same influence which pervades it, until the conductor has attained a high electric potential. Oftentimes the opposite conductor is far from being equally charged, and in this case a great strain is brought to bear on the insulation between the two sides of the circuit. To relieve this strain the little device known as the lightning arrester is used.

The simple and fundamental principle of the lightning arrester is some form of an air gap with serrated or plain surfaces. The only changes made have been the addition of circuit interrupting or arc prohibiting features which the different currents employed have necessitated. The success or failure of lightning arresters in general can be attributed mainly to the successful or unsuccessful performance of the duties devolving upon these additional features.

There have been very few of the numerous forms of lightning arresters devised which have not in one form or another employed the air gap. The chief reason for the employment of the air gap, in preference to that of substituting some form of resistance, is that it is of variable resistance, depending upon the conditions; under ordinary circumstances it is a splendid insulator, but to a discharge it offers far less impedance than an artificial resistance of much less resistance.

It is found also that the dynamic currents of high potentials will leap certain air gaps and permanently establish a flow. Thus we have to guard against the employment of too small an air gap and still not have it so large as to prohibit a free passage of the discharge. Having determined the proper and most advantageous air gap, we have yet another problem with which to baffle; that is, a means of automatically opening the lightning arrester circuit, should an arc be established.

At this point we have all come to a halt. There are, however, a few who apparently have employed better methods than others, and have been enabled to get very good results. One of the original ideas for accomplishing the desired effect was the addition of a fuse to the air gap, so that when the flow of current was established the fuse would be blown, and in this manner the circuit restored to normal, but we were not satisfied with this form of an arrester, for we wanted something which did not require constant attention aside from being unreliable in case of discharges following in quick succession, and thus proving a constant source of annoyance.

The next step in advance was the increase in the number of fuses placed in multiple. But even this must be carefully watched and regularly inspected. To overcome the annoyance of blown fuses and interrupted service, various methods have been employed. Among those best known is the "air jet arrester," which automatically blows out the arc by a jet of air forced from a chamber in which an arc has been established in series with the outside arc. By the expansion caused by the heating of the air in the chamber the air is given impetus, and when directed upon the arc it tends to blow it out; but even this form of arrester proved inadequate and unsatisfactory.

An early principle and one which is recognized to-day as fundamental, is that of the magnetic blowout with which you are all familiar. Other and various forms have been used, such as the iron and mica washers, "Keystone," "tank," etc., but in many of these forms either the mechanical portion has been a drawback or the construction was such as to render a barrier rather than an inducement to the discharge.

The tank arrester has in most instances proved very satisfactory. The two chief drawbacks are the constant consumption of energy while in circuit and the possibility of a storm approaching without warning and finding you without your tank cut in.

I think that I may safely say that there are three forms of arresters being used to-day which are considered standard. They are the Wurts non-arcing, the G. E. magnetic blowout, and the Garton. In the non-arcing and magnetic blowouts different methods of construction are employed in dealing with the various currents, while in the Garton the same form and same principle enter into the arresters for all of the different currents.

After describing the two former arresters, the author stated that in the Garton arrester the idea is to provide the best possible course for the discharge and to instantly cut off the current flow after the discharge. This is done by providing as straight a path as possible, with ohmic resistance reduced to a minimum and no inductive resistance at all.

In the Garton arrester, that which prohibits the constant consumption of energy or the flow of normal current to earth is the employment of an air gap. After the discharge has leaped the air gap and a flow is established, the small coil or solenoid becomes a magnetic field and the small plunger is suddenly drawn from its contact in the tube. The act of drawing the plunger from its contact establishes in the circuit a secondary arc which, being in series with the originally established arc, instantly interposes an additional resistance which goes on increasing by reason of its lengthening until the circuit is broken. Another means of destroying the arc is that of elongating it in the tube, which prohibits its assuming its natural form. The element of time also enters greatly into this device, from the fact of its being mechanical in its operation.

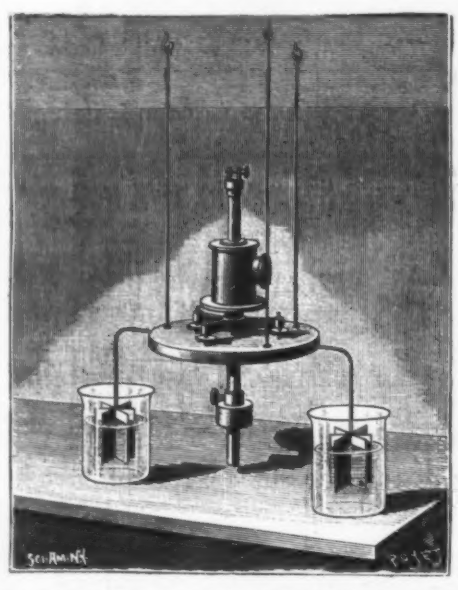
True it is that in many instances lightning arresters have not proved a source of protection, but in nearly every instance it will be found that the fault lies somewhere in the installation and not in the apparatus, which is generally the first to be condemned.

Trouble invariably occurs in circuits which are inadequately equipped. No station, whether direct or alternating, should be operated without the insertion into every feeder of a kicking coil in conjunction with the lightning arrester. This applies to street railways as well as stationary motors, but it is not necessary on series arc circuits. Different circuits require different localities for the installation of arresters. For instance, on railway circuits we equip each car and station feeder and scatter them along the line at varying intervals from one-half to one mile apart, and at the terminals, while on alternating circuits we place arresters at the individual transformers or banks. But there is one thing that should not be tolerated, and that is to make a lightning arrester a part of or in any way connected with a transformer. It should be the purpose to keep the lightning just as far from the transformers as possible, for, although of high inductive resistance, they can very rarely ward off disruption unless they are supported by some good lightning arrester.

* Abstract of a paper read before the Northwestern Electrical Association.—From the American Electrical Engineer.

SUPPORT FOR ARRESTING VIBRATIONS.

THE vibration of the earth in cities is, as well known, extremely annoying to those who have to



PROFESSOR JULIUS' GALVANOMETER, WITH DEVICE FOR ARRESTING VIBRATIONS.

manipulate delicate apparatus. An endeavor has been made in many ways, but without entire success, to give such apparatus greater stability.

The best arrangements employed up to the present consist in floating the base of the instrument in a vessel full of water or mercury, and assuring an invariable position for it by sustaining it very slightly by means of threads or small chains that stretch but little. But the use of a liquid is always accompanied with some difficulties of installation that have prevented it from becoming general.

The question seems to have been recently solved in a very happy manner by Prof. Julius, and the data that we have been able to gather as to the efficiency of his arrangement are all to its advantage.

The idea is simple. The platform that carries the instrument that it is desired to render immovable is suspended at three equidistant points by three metallic cords forming the edges of a vertical prism and fixed at their upper extremity to a horizontal beam or simply to the ceiling of the laboratory. It is essential that the cords shall have equal tensions.

The vibrations that reach the upper part of the cords are generally very rapid, and the horizontal displacements of the whole will not produce any pendular oscillations of the platform, the period of the motions being extremely different. Seismic waves alone will produce pendular motions, but they are exceptional and need not be taken into account.

There is but one kind of motion to be feared, and that is the one that occurs without a proper period and that is consequently capable of taking on all others around an axis passing through the center of gravity of the rigid ensemble suspended from the three cords. Let us suppose, in fact, that an impulsion, descending simultaneously through the three cords, reaches the platform and tends to communicate a horizontal motion to it. If the center of gravity of the suspended piece is above or below the plane containing the three points of suspension, the platform will have a tendency to revolve around a horizontal axis, and this will bring about a swinging of the apparatus. But if the center of gravity is situated precisely in the plane of these three points, there will be no tendency toward rotation, and the only motion that can possibly occur will be a long period oscillation of the entire apparatus operating as a pendulum. Now we have seen that motions of this kind are scarcely to be feared, because of the want of concordance of the durations of the two motions. It may chance, however, that by accident a series of impulsions reaching the plate shall be of such a nature as to add themselves and tend to give it a swinging motion that is no longer negligible. Such motions will be rapidly annuled if we introduce some sort of deadening device into the system. The arrangement adopted by Prof. Julius consists in fixing to the platform two plates of metal, simple or stellate, that are made to enter a vessel containing oil or glycerine. The same result is reached by substituting for the plates two balls of wadding that are made to rest delicately upon a table.

The position of the center of gravity of the system is very easily regulated by means of a weight that is made to slide along a rod adjusted to the lower part of the platform. By a few tentatives, we thus succeed in finding the position of this additional weight that gives the apparatus its maximum of stability. It is useless to calculate the equilibrium of the platform accurately. The rigidity of the attachments, the entrainment of the deadening liquid and other causes would render such caculations illusory. The best process consists in trying to get the instrument in a state of rest while a friend indulges in a wild dance in the story above.—La Nature.

[Continued from SUPPLEMENT, No. 1080, page 17270.]

A COMPLETED CHAPTER IN THE HISTORY OF THE ATOMIC THEORY.*

WE have, then, eleven series of determinations of the atomic weight of oxygen. One of these, for reasons which, so far, are chiefly matter of conjecture, differs much from the mean of all the others. These other ten are concordant; they differ, on the average, only one part in twenty-two hundred from their mean, and the greatest difference from the mean is about one part in a thousand.

Since these experiments have been made by different processes, by different men, under varied conditions, and since the greatest difference from the mean of the whole is only one part in a thousand, it is probable that the mean of all differs from the truth by much less than one part in a thousand. The errors of our experiments are of two kinds, accidental and systematic. If we shoot a hundred times at a mark, about half of our shots fall a little to the right and about half a little to the left. These are accidental errors; accidental errors are lessened as our manipulation improves, and they but slightly affect our final mean. Systematic errors affect all our results in the same direction. Suppose we fire a hundred shots at a target one thousand yards distant, not examining the target till the shots are all fired. If, now, the sights of our rifle were set for five hundred yards, all our shots would strike too low. This is a systematic error; systematic errors diminish as our knowledge increases.

Accidental errors can be rendered harmless by taking the mean of numerous determinations made by the same method. But systematic errors must be detected and avoided. That they have been detected and avoided in any given case can never be definitely known; it can, at best, be presumed from the fact that experiments by different methods give the same result.

As to the atomic weight of oxygen, accidental errors have now been fairly eliminated, and we can make definite numerical statements on this point. If each of the ten sets of experiments were to be repeated with the same skill and knowledge, there is not one chance in a thousand that the new mean would differ from the present mean by as much as one part in sixteen thousand. Again, if ten new sets of experiments were to be made by new methods and new experimenters, there is not one chance in a thousand that the new mean would differ from the present mean by as much as one part in twenty-five hundred.

As to possible systematic errors, modesty in statement is incumbent on all scientific men. But we have now ten independent results in which the difference from the mean is at most only one part in one thousand. We may then fairly assume that the systematic error of the mean is less than one part in one thousand. Again, we have lately been able to take one step in advance, which throws needed light on precisely this point. It has been found possible to weigh some hydrogen, to weigh the requisite oxygen, and to weigh the water which they produce. If, now, there were some undetected systematic error in weighing either one of these three substances, occasioned, for instance, by some impurity remaining undetected in one of them, the sum of the weights of the hydrogen and oxygen would differ from the weight of the water produced. If a pound of sugar and a pound of water produce only one pound and three quarters of sirup, there was a quarter of a pound of sand in the sugar. Now it has, I think, been proved that, if the sum of the weights of the hydrogen and the oxygen is not precisely equal to the weight of the water produced, the difference is too small to be detected, and cannot be more than one part in twenty-five thousand. If there really were a difference of this amount, and, further, if this difference were due to an error at the precise point where it would be the most mischievous, it would render the atomic weight of oxygen uncertain by one part in about twenty-eight hundred.

Taking into account the presumption from the concordance of the results of different experimenters and the presumption from the agreement just mentioned, I think we are justified in assuming that the remaining systematic error is not more than one part in sixteen hundred, and that it probably is not more than one part in three thousand.

If this is a reasonable assumption, the net result of the experiments made in Denmark, France, Great

* Address by Edward W. Morley, the retiring president of the association.

Britain and the United States is that the atomic weight of oxygen is between 15·87 and 15·89, and that probably it is between 15·875 and 15·885. By no stretch can we imagine that the truth lies in the whole number 16·00, nor in the even fraction 15·50. We cannot sanely believe it to lie in the number 15·75, having modified Prout's hypothesis into the new statement that all atomic weights are divisible, without remainder, by one-quarter of the atomic weight of hydrogen. It will be obvious that, if we are still resolved to accept some form of the attractive illusion, we must assume that the true divisor is as small as one-eighth of the atomic weight of hydrogen, for the value 15⅞ is included within the limits given.

Then there is one small and well determined atomic weight which utterly refuses to support Prout's hypothesis or any modification yet stated by believers in the hypothesis. Further, now that the atomic weight of oxygen is well established, we can compare, with hydrogen taken as unity, the seven other small and well determined atomic weights which have been mentioned.* We see that every value differs from an integer; for lithium, nitrogen and potassium, the difference is about one part in two hundred and thirty; for sodium, sulphur and chlorine, about one part in one hundred and eighty; for carbon and oxygen about one part in one hundred and thirty. On the average, these values, which are the best determined in chemistry, differ from whole numbers by about one part in one hundred and eighty. There is less than one chance in a thousand that these numbers can possibly be so much in error. These are the numbers best fitted to test Prout's hypothesis; and their evidence against it is decisive.

It ought to be added that the evidence against Prout's hypothesis seemed to many to be decisive, even without the knowledge of the atomic weight of oxygen which has recently been acquired. But the evidence can now be stated in a much more direct and simple manner; and it has gained in force, for to the seven fit instances at hand before there is added an eighth, which happens to be the most weighty of the whole.

In order to present the evidence against Prout's hypothesis when we lack an accurate knowledge of the atomic weight of oxygen, we have first to assume this value. We may, for one trial, assume that this value is the whole number 16·00, which is required by Prout's hypothesis, and see whether, on this assumption, the other seven atomic weights in question are very nearly such as the hypothesis requires.† But the average deviation from the numbers required by the hypothesis is one part in five hundred, and one deviation amounts to more than one part in three hundred. We may make another trial by assuming for oxygen, not the whole number 16·00, but that value which shall make the sum of all the deviations the least possible; and we may also take one-quarter of the atomic weight of hydrogen as our divisor.‡ But the average deviations from the numbers required by the theory are, even in this case, one part in six hundred; and the atomic weight of that element for which the determinations of friends of the hypothesis agree with those of its opponents to one part in thirty-five hundred, is supposed, after all, to be in error by one part in five hundred. The atomic weight of oxygen, computed expressly to give every possible advantage to the hypothesis, differs from the whole number required by the theory by one part in two hundred and fifty.

We read in our school books of the bed of Procrustes, to which the tyrant fitted his compulsory lodgers; if they were too short, he stretched them on the rack, if they were too long, he lopped off the superfluous length. This fable was really a prophetic vision; the bed is Prout's hypothesis; our friends who admire it want to stretch the most unyielding quantities, and to lop off numbers which have been determined with the greatest precision. Either the experiments are in error by an amount which seems incredible or the hypothesis is an illusion. If the supporters of the hypothesis would avoid the conclusion, they must supply better determinations, or they must detect real and tangible sources of error in those already made.

The hypothesis was most interesting and attractive; it promised, if sustained by experimental evidence, to give the means of such insight into the nature of matter and into the intimate structure of atoms that it was well worth all the attention which has been given to it. That it should fail of support, that its promises could not be kept, is a matter of regret; but it is time to recognize that our hopes are quite cut off. That other elements are composed of the same substance as hydrogen may or may not be true; but we have now no hope of proving it by determinations of atomic weight. It would not be difficult, perhaps, to modify Prout's hypothesis again and again, so as to bring it into some accord with the facts. We may imagine, if we will, that the observed numbers, if determined without error, would all be divisible by the eighth part of the atomic weight of hydrogen, or the ninth, or the tenth, or by some smaller fraction. But such a hypothesis is of no interest and of no utility, because it is incapable of proof or disproof by experiment. The reason is obvious. If we suppose that all atomic weights are divisible by one-tenth of the atomic weight of hydrogen, then, in case the theory is erroneous, the average deviation of the actual atomic weights from those required by the theory is only one-fortieth of the unit. The man who supports a theory which has no physical basis would assert that all such ascertained deviations were due to errors of experiment. Others would reply that you cannot prove that a man is a good marksman by crowding the targets so near each other that not even his random shots can miss them all. But his backers might make so uncritical a claim.

No; Prout's hypothesis, if subdivided far enough, may be true for all which can be proved with the balance; but in such new form it is of no use and of no interest, for it cannot be proved so as to become a safe basis for further inference. In its present form, there is no root of truth in it.

So far, I have argued that Prout's hypothesis is not true as heretofore enunciated; and that, if some further modification of it is true, we cannot know it.

This conclusion has been sustained by the evidence of the chemist's balance. A conclusion supported by a single kind of evidence may command the confidence of one who has been long familiar with the evidence, and who has become capable of weighing it. But, for others, the concurrence of evidence of different kinds rightly adds greatly to its cogency. In this case, there is such concurrent evidence. There is other proof that the atoms of some well studied elements are not additive structures. Let me briefly describe the nature of this evidence.

When certain elements are volatilized in a colorless gas flame, or in the electric arc, their molecules are made to vibrate, so as to produce light. By the study of this light we can in time learn much of the nature of the vibrating system. The observed facts are gradually reducing to order; and one result is very striking. In the case of three closely similar elements before mentioned, lithium, sodium, and potassium, the complexity of vibration is precisely similar in all, and the numerical relations among the component vibrations are precisely similar in all. Therefore we are compelled to assume that the complexity of structure is the same in all, and that the relations of the component parts, and of the forces acting between them, are the same in all. To illustrate the nature of the argument: the complexity of vibration and the numerical relations among the component vibrations in the case of a large church bell are precisely similar to those in the case of a bell only one-third as large. Then, even without the direct evidence of other senses, we must presume that the two bells are similar structures, having similar parts, similarly related. We cannot believe that the larger bell is made of a small bell loaded with weights, nor of three small bells bound closely together. The larger and the smaller are of the same order. The larger is not made of more parts than the smaller; it is made of more metal. So with the atoms of these three elements; the larger are not made up by the addition of parts which preserve their identity and remain undivided. But all we know of chemical combination relates to structures which are made by the addition of parts which preserve their identity and remain undivided. Then Prout's hypothesis assumes an analogy which does not exist; and deductions from an imaginary analogy will themselves differ from the truth, much as fairy tales differ from history.

There are still other sources of evidence drawn from the specific heats of the elements; the evidence is of the same kind, and leads to the same conclusion, but I simply allude to it.

It seems to me, then, that the exact quantitative similarity of the spectra of these elements shows that they are not compounds one of another, subject to the great chemical law of the addition of undivided parts; and that also the magnitudes of the small and well determined atomic weights differ from the values hitherto suggested by applying the law of the addition of undivided parts, and differ by five, ten, and fifteen times the greatest experimental error we can reasonably assume.

So the citadel which defends the secret of the atom cannot be taken by way of Prout's hypothesis. We have carried on the assault for eighty years, and we are now satisfied that the way is blocked; we tried to breach, not a wall, but the solid mountain itself. We shall doubtless learn the structure of the atom, but we cannot learn it in the way we hoped. This chapter in our study of the nature of atoms has been fully ended.

If Prout's hypothesis cannot serve us, you will doubtless ask what other ways are open by which we may learn something of the structure of atoms. To answer is difficult; to answer adequately is impossible. Perhaps I may mention four lines in which it has been hoped by some that the desired advance could be made, and may indicate what it is reasonable to expect of each.

One of these indications of a possible source of knowledge as to the structure of atoms was suggested by certain chemical observations on some of the rare earths. My brief explanation will not do justice to the conception of the eminent chemist who investigated the phenomena. As I have said, the atom is something which, as a matter of fact, remains undivided in all chemical changes. Most atoms seem to resist every force which we can apply. But it is possible that the amount of resistance which they can offer may vary greatly: it may be that in the case of some elements the resistance is such that in some reactions the atoms remain undivided, and not in others. From the study of such cases, if there are such, we might expect much help. Now, in the case of the common and well studied elements, the occurrence of such cases has not been suspected; but some of the rarer elements, examined by a process which is frightfully laborious, have exhibited phenomena which suggest, as a hypothesis to be further studied, such a subdivision of atoms. But it is probable that we have mixtures of distinct elements which we do not yet know how to separate from each other by simple analytical processes. This chapter, we may fairly presume, will be valuable; but not because it will tell us anything new about the structure of atoms.

Certain spectroscopic phenomena have suggested that some elements may be decomposed by the action of a high temperature. For instance, it has been thought not impossible that, at the temperature of the electric arc, potassium compounds quite free from sodium should begin to show the spectrum of sodium, because at this temperature potassium is decomposed so as to produce sodium. This hypothesis has been carefully investigated; in part, by the accomplished physicist who is its author; in part, at his suggestion and invitation. It is found that, if years are given to the preparation of potassium compounds free from every trace of sodium, then it is impossible to obtain from them any phenomena suggesting a decomposition into sodium. Here, again, the new chapter, as far as it relates to the structure of the atom, is likely to be but short.

A third suggestion did not rest upon any observed chemical phenomena, but was a purely intellectual creation. This is the hypothesis that atoms are vortex rings in a frictionless fluid. It belongs to the mathematical physicist, rather than to the chemist, to discuss this interesting suggestion. It may be said that it has seemed not impossible that the chemist should find a vortex ring capable of exerting certain chemical forces. But the fate of the hypothesis rested, not with the chemist, but with the mathematical physicist; and it has been found that the theory demands that the weight of a body composed of vortex atoms should increase with rise of temperature. It is scarcely possible that this can be the fact; if, then, the mathematical and physical reasoning involved is sound, it is scarcely possible that atoms consist of vortex rings. The probability is therefore but small, that we are to learn of the nature of atoms by means of this hypothesis.

Some spectroscopic and other optical phenomena seem to promise more light as to the structure of molecules and atoms, though the dawn is not yet. Thanks to the concave grating, we can determine the frequency of vibration of the light from any source with great accuracy. When the light is complex, we can determine, with great accuracy, the relative frequency of the component vibrations. In the cases which have been best studied, the observed frequencies have been reduced to rather simple numerical relations. From the study of these relations we may expect, in time, to determine the structure of the vibrating systems. But the way is long and difficult. Let us illustrate the nature of the method by means of a familiar example, namely, by the study of the structure of a sonorous vibrating system by means of the study of the sonorous vibrations produced by it.

Let us suppose a person deprived of the sense of hearing, but master of the whole mathematical theory of sound. Suppose, further, that he has an instrument which will do for sound what the spectroscope will do for light. With this instrument, let him observe the frequency and the relative intensity of the vibrations produced by certain musical instruments which we cause to vibrate for him, but withhold from his inspection. Let us, first, sound for him a single note on a piano. The vibrations produced are, as you know, somewhat complicated. Our imagined experimenter, with his instrument, observes vibrations whose frequencies are 100, 200, 300, 400, 500 and 600 in one second; and he also observes that the vibrations of 100 and 500 are of nearly equal intensity, that the vibrations 200, 300 and 400 have more than twice as great an intensity, and that vibration 600 is very feeble. From these facts, if his attainments are sufficient, and his imagination sufficiently fertile, he can determine what system produced the sound. He imagines every possible vibrating system—drum, cymbals, trumpet, flute, organ pipe, harmonium reed, violin string, piano, harp and more. Next, assuming each imagined system of such size or tune as to produce one hundred vibrations a second for its gravest tone, he computes what other vibrations will also be produced and what the intensity of each. He finds, for instance, that a closed organ pipe will give only the frequencies 100, 300, 500, but will not produce the other observed frequencies 200, 400, 600. Therefore, he concludes the sound we produced for his study is not due to a closed organ pipe. He finds, after many trials, that the observed frequencies and intensities could be produced by striking a stretched cord with a soft hammer, at a definite point near the end of the cord, so quickly that the cord and hammer remain in contact about the six-hundredth part of a second, and that the observed phenomena could not be produced by any other of the imagined vibrating systems. Then he concludes that the observed sound was probably produced by the stretched cord of a piano. He will have detected the true system, by first imagining every possible system, by computing the frequencies and corresponding intensities due to each hypothetical system, and by then comparing computation and observation.

For a second example, suppose we ring, for our imagined observer, a bell of a certain form, and that he notes the frequencies 200, 475, 845 and 1295 in one second; in which, also, he finds that the vibration 845 so predominates as to give its pitch to the compound tone. Our observer will not be able to refer this sound to any stretched cord, or to any organ pipe or other wind instrument; for all these are limited to frequencies contained in the series 200, 400, 600, 800. A uniform metallic bar, suspended and struck like the triangle of an orchestra, will give frequencies not contained in this list, but they will be 200, 550, 1080 and 2670, instead of 200, 475, 845 and 1295. But if our observer has adequate powers, he will imagine a hemispherical bowl of suitable dimensions, and will, in imagination, add mass and rigidity in suitable places, until, in time, he will have devised a system whose computed vibrations agree in frequency and in distribution of energy with those of the invisible sounding body. Then he would conclude that the observed sound was due to a bell of the form assumed in the successful computation.

This illustration sketches imperfectly, I fear, the laborious method by which we may learn the structure of a vibrating system from a study of the vibrations produced by it. When we attempt to use this method in order to learn something about the structure of molecules and atoms, our powers of imagination and our mathematical skill are none too much. We know but little which can suggest plausible hypotheses. The facts which are to be explained have been but recently reduced to order. Accordingly little has been actually accomplished. But there are some few examples of the use of this method of studying the structure of molecules and atoms.

In one such example, the structure imagined consisted of a system of concentric spherical shells, each connected with the adjacent shells by springs. This complicated structure admits of relatively simple computation, and was taken because it fairly well represents a rather simple imagined structure, for which, however, computation is difficult. But it was found that the results computed on this hypothesis gave little promise of agreement with facts.

This was a dynamical hypothesis; it suggested, not only vibrations, but the forces which were to produce them. A second example suggests certain possible motions, but not the forces which might produce the hypothetical motions; it is not dynamic, but kinetic.

As we know, many of the lines in the spectra of the elements are double. For instance, when a volatile compound of sodium is brought into a colorless gas flame, this is colored yellow. When we examine this yellow flame with a spectroscope of sufficient power, we see that there are two frequencies, differing from each other by only one part in a thousand. Now it is probable that these two frequencies are due to the vibrations of one and the same body. There are many illustrations of the fact that a given body may perform

* The values are as follows: Li = 6·97, C = 11·91, N = 13·94, O = 15·88, Na = 22·87, S = 31·83, Cl = 35·19, K = 38·84.

† The values on this assumption are as follows: Li = 7·02, C = 12·00, N = 14·04, O = 16·00 (assumed), Na = 23·07, S = 32·04, Cl = 35·46, K = 39·11.

‡ The values are as follows: Li = 7·00, C = 11·96, N = 13·99, O = 15·94, Na = 22·96, S = 31·96, Cl = 35·33, K = 39·00.

two different vibrations whose frequencies differ but slightly. For instance, if we suspend a ball by means of a cord and let it oscillate as a pendulum, it is well known that a swing of six feet takes a little more time than a swing of three feet. Suppose, then, that we let our ball swing six feet north and south, and also three feet east and west at the same time; the two motions may be combined so that the ball moves in an ellipse—an ellipse whose longer axis is north and south. If the longer and the shorter swing had precisely the same frequency, the axis of the ellipse would continue in this direction; but since the frequencies differ, the ellipse slowly revolves. Conversely, from the revolution of an ellipse, we should infer a difference of frequency in the two component vibrations. So it is suggested that the two slightly different frequencies in the light sent out by ignited sodium are due to an elliptic motion in the molecule in which the elliptic orbit slowly revolves; this suggestion has not yet been carried so far as to specify any hypothetical cause for the revolution of the ellipse.

These two examples, both due to eminent English physicists, may serve to illustrate the method by which, if I am not mistaken, we are not unlikely to learn much as to the structure of molecules and atoms. We must not expect rapid progress. Even comparatively simple hypotheses may require for their due examination the invention of new mathematical methods. And useful hypotheses are rare: like the finding of buried treasures, they are not to be counted on. But, since Prout's hypothesis has rendered us its final service, new hypotheses must be devised, competent to guide us further on our way. Let us hope that, before this city again honors our association with its invitation to meet here, American chemists and physicists may have had some honorable share in such new advance.

THE ARMY WORM.*

The recent outbreak of the army worm has caused much alarm among farmers throughout the State [New York] and also much apprehension as to the probability of another serious invasion this season. Judging from our correspondence, there is a general desire among farmers, especially among those who have suffered from the depredations of the caterpillars, to know something of the life history and habits of the insect. Many are also inquiring if it is advisable to make further effort to prevent the increase of the worms during the remainder of the summer.

With this in mind the following brief bulletin has been written, in which the life history of the insect is given, together with a statement of such facts relating to the invasion as are judged to be of especial interest at this time. The short time necessarily allowed in the preparation of this bulletin precludes anything more than a brief review of the subject.

THE EXPERIENCE OF THIS SEASON.

Extent of the Invasion in the State.—During the past three weeks, letters and telegrams have been received at the station from various sections of the State giving accounts of the ravages of the army worm and asking advice as to the best known methods of checking the onward march of this destructive pest. Circular letters and telegrams were sent in reply giving instructions and suggestions. Up to date letters have been received from twenty-eight counties representing the more important agricultural sections of the State.

Although the attack has been widespread, the damage done seems to have been most keenly felt in those sections of the State which are devoted largely to dairying and stock raising. In these sections oats, corn, rye, wheat and timothy are extensively grown, while thousands of acres are reserved for pasture. Unfortunately the army worm feeds chiefly upon the crops above mentioned and has been especially destructive this year to both corn and oats. Add to this the fact that, owing to the comparatively dry weather during the past two years, the hay crop this season is unusually light, and it will be readily understood that this invasion of caterpillars has been an especially serious matter to many farmers.

The Invasion an Unusual One.—This invasion of the army worm is one of the worst in the history of the State. Old residents say they have never before experienced such destruction to their crops by caterpillars of this kind. The amount of damage done would be difficult to estimate. Farmers in various sections of the State report that the oat and corn crops were practically ruined. In many cases the oats were cut and hauled to the barn with the worms still clinging to them. This soon produced such an unhealthy condition in the stacks that removal of the grain to open air was made necessary. Where the caterpillars attacked corn, the crop was usually ruined very quickly unless vigorous efforts were at once made to check the advancing insects.

In other States, including Pennsylvania, Massachusetts, New Hampshire and Michigan, a similar invasion is reported. We have sent letters to the entomologists of the various stations to ascertain the extent of the outbreak.

ACTION THAT IS ADVISED NOW.

Treatment of Previously Infested Fields.—As we shall see later on, the caterpillars are now passing through the pupa stage. They have previously sought shelter under stones, bunches of dried grass, under pieces of board, bits of wood, along the fences under various kinds of rubbish, or have burrowed into the ground to a depth of an inch or two. In each case they have made for themselves snug cells of earth, or bits of rubbish and earth combined, as the case may be. In these retreats the wonderful transformation from an active caterpillar to an apparently lifeless creature takes place.

It is evident that, by destroying these pupæ, the moths will not be allowed to develop. This also means the destruction of many eggs. When practicable, therefore, it is desirable to burn over grass land and stubble where the caterpillars have been. When it is not practical to burn the fields over, and where the surface of the ground is moderately even, a heavy roller may be used to advantage. In addition to this, it is well to clear up all rubbish in the infested fields; also along the fences and in the fence corners bordering such fields. From our observations in the field, it seems evident that, when about to pupate, the caterpillars not only retreat under stones and rubbish, but many of them find refuge under the matted grass in the fence corners and around the borders of the fields. In districts where infested fields adjoined the roads and especially where the caterpillars were known to have crossed the road, a careful examination should be made along the fence and under stones, rubbish, etc., along the roadside. If any pupæ are found, the infested section should be burned over if it is practicable to do so. Many of the pupæ can be gathered by hand and killed by dipping in kerosene oil or by crushing. Where furrows were plowed to check the insects, and especially if the holes were omitted, the dead grass and rubbish along their borders should be carefully examined.

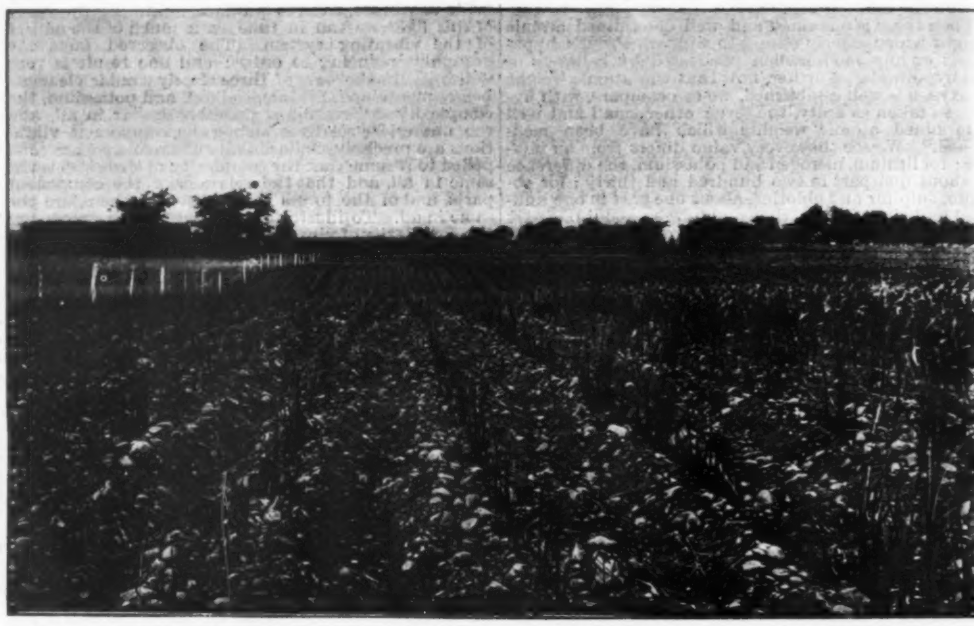


Fig. 1.—VIEW OF A CORNFIELD WHERE THE ARMY WORMS WERE SUCCESSFULLY CHECKED BY FURROWS BETWEEN THE ROWS OF CORN.

Crops Attacked.—Although the army worm feeds on a variety of plants, the grasses and grains are its favorite diet. In most cases, corn and oats seem to have suffered most severely. We have observed the caterpillar this season feeding on timothy, corn, oats, rye, barley, wheat, and the report has come to us that in one section of the State the bean crop was seriously attacked.

Crops to Take the Place of Corn and Oats Destroyed by the Army Worm.—With many farmers the ravages of the army worm have doubtless caused a serious shortage of fodder crops for fall and winter feeding. There appears to be no way of entirely making good this deficiency from crops which may be produced this season.

In those cases where corn was intended to be used as a fall soiling crop, barley and peas may be grown as a partial substitute. This mixture may be sown as late as August 10 at the rate of two bushels each of barley and peas. The crop is not injured by frost and will furnish green fodder during October.

If more is grown than what can be fed green, the excess may be preserved in the silo with fair success, although the silage will be inferior in quality to corn silage.

Where crops are destroyed by the army worm as early as the first week in July, Hungarian, if sown at once, will produce an abundant crop which may either be fed green or cured for hay.

LIFE HISTORY.

Name and Classification.—The popular name "army worm" comes from the abnormal habit of the caterpillars, or "worms," as they are incorrectly called, of moving in great armies in search of food. The scientific name of this species is probably Leucania unipuncta, although it has been suggested that this may be the species known as Leucania albilinea or, popularly, the wheat head army worm, as, when attacking wheat, barley, or rye, many of the heads are found cut off by the caterpillars. These army worms belong to a large family of insects known as the Noctuidae, which includes the night-flying moths. It is also interesting to note that this insect is closely related to some of our most destructive cutworms.

Some Habits of the Army Worm, Leucania unipuncta.—Although unsuspected by most of us, the army worm is present in some of our fields every year. The grass land is its natural home. The caterpillars are usually found in those places where the grass grows most luxuriantly. Here they may remain season after season, one brood following another, feeding unnoticed almost before our eyes. It is not until meteorological conditions are favorable for them, however, that the abnormal increase occurs. It is only at such times that the unusual habit of moving in vast armies is developed. As a rule also, it is said, the caterpillars are usually nearly half grown before the march in search of food begins. They seem to be especially ravenous at this time, and the rapidity with which a field of grain may be ruined is truly surprising. An acre or more of corn may be destroyed in a single night. The caterpillars usually feed more rapidly at night than during the day, although they are very active on cloudy days or during the cool of a bright day.

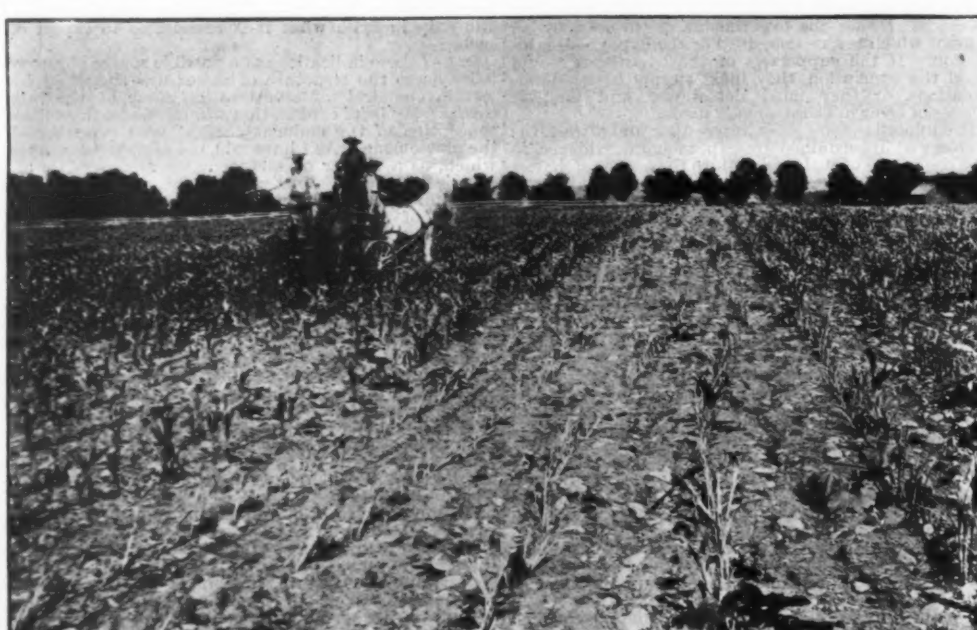


Fig. 2.—VIEW IN A CORNFIELD WHERE A STRIP ABOUT A ROD WIDE WAS BEING SPRAYED WITH POISON TO CHECK THE ARMY WORMS.

Life History and Descriptions.—The life history of the army worm, Leucania unipuncta, together with descriptions of the different changes which take place during the life cycle, may be briefly stated as follows: the ma-

* By V. H. Lowe, entomologist New York Agricultural Experiment Station. Text and illustrations from Bulletin 104 of the station, Geneva, N. Y.

ture insects are dull brown moths having a white spot in the center of each anterior wing. When the wings are spread, a single female moth will measure over an inch and a half from tip to tip. The body is about three-fourths of an inch long.

The eggs are very small, globular in form and nearly white in color. They are usually laid in the leaf sheaths of grasses and grains, the terminal sheath being most frequently selected. According to Dr. Riley* the early brood of moths oviposit freely "in the cut straw of old stacks, in hay ricks and even in old fodder stocks of corn stalks." He also adds that "old bits of corn stalk upon the surface of the ground in pastures have been repeatedly found . . . with hundreds of eggs thrust under the outer sheaths or epidermis, while the last year's stalks of grass in the fields around Washington have been found to contain these eggs in similar position." Dr. Riley also states that, lacking both stubble and fodder stalks, the moths will deposit their eggs in fields of winter grain. In this connection it may be stated that in several cases with which we are familiar the caterpillars evidently came from fields of winter rye to attack other crops, leaving the fields very soon after the rye was cut. Dr. Riley found that a single female moth is capable of depositing from five hundred to over seven hundred eggs. This wonderful prolificacy explains in part at least why, under certain meteorological conditions which favor the development of the eggs, the caterpillars appear in such vast numbers. In seasons when the army worms are not unusually abundant it is probable that only a small percentage of the eggs hatch.

The young caterpillars come forth in about ten days from the time the eggs are laid. In case the eggs were placed on fresh grass or grain, the young larvæ feed for a time in the sheath where the eggs were placed, but finally include the whole blade in the bill of fare. They are full grown in about four weeks. At this time a single larva measures about an inch and a half in length and a quarter of an inch in diameter. They may be briefly described as being smooth, naked caterpillars, moderately dark in color, with longitudinal stripes running the full length of the body. A broad, dark stripe is especially prominent along each side.

The third stage in the insects' life begins when the caterpillars go into the ground or under stones or rubbish to make the wonderful change from an active caterpillar to an apparently lifeless creature. This stage is called the pupa stage or, in the case of butterflies and moths, is more familiarly known as the chrysalis stage. A single chrysalis measures about three-fourths of an inch in length. They are at first light brown in color, but soon change to a deep chestnut brown. The moths come forth in about two weeks. There are probably two or three broods every year in the more Northern States. It is usually only the first brood of the season, however, which occurs in such unusual numbers.

Hibernation.—The caterpillars of the last brood of the season are but half grown when winter overtakes them. For protection they hide away under any convenient shelter, where they become very sluggish, in which condition they remain until spring. The moths from this brood of caterpillars come forth quite early in the season. As above noted, it is this generation of moths which, under favorable circumstances, produce the vast armies of caterpillars such as we have witnessed this summer.

NATURAL ENEMIES.

Fortunately, nature takes a hand in checking the onward march of such armies as these. Judging from our observations in the field and from specimens sent us, the present generation of army worms is being seriously crippled by several species of parasites and predaceous insects. We have also found many of the caterpillars attacked by a fatal bacterial disease which seems to resemble the bacterial disease of cabbage worms. In one or two instances it was estimated that twenty-five per cent. were attacked by this disease. Of the parasites referred to, one of the most prominent is a species of Tachina fly. This active little insect resembles a house fly in general appearance. The Tachina fly lays its eggs on the backs of the ill-fated caterpillars just back of the head. Many caterpillars were found with three or four of those small, white eggs attached. Few, if any, such caterpillars reach maturity, as the eggs soon hatch into minute white maggots, which burrow through the skin to feed on the fleshy tissues beneath. The maggots grow rapidly, and soon the unfortunate caterpillars succumb, although not until the maggots have had sufficient food to meet their wants. Among the most prominent predaceous insects which were found attacking the army worms were the fierce larvæ of some of our common ground beetles. Some of these larvæ grow to nearly the size of the cut worms themselves. They are very active and fight fiercely for the mastery over their prey, which they grasp in their strong jaws and endeavor to hold firmly while sucking the victim's juices. Several species of birds also feed upon the army worm.

METHODS RECOMMENDED FOR CHECKING THE ARMY WORM.

The methods which are usually recommended for checking the army worm are mainly these: Plowing deep furrows around infested fields or around an infested section of a field; also, where possible, in front of the army of advancing insects. It is better to make the sides of the furrows as near perpendicular as possible and, where the soil will permit, to slant them back, especially the side opposite the infested section. Holes should be dug in the furrows at intervals of from ten to fifteen feet. The caterpillars which fall into the furrows, not being able to get out, will crawl along the sides, finally falling into the holes, where they may be easily killed by crushing or by the application of kerosene oil. The caterpillars in the furrows may also be killed by scattering straw over them and burning it, or they may be crushed by a log drawn back and forth through the furrow. Fig. 1 is from a photograph of a field of corn in which the advancing army of caterpillars was successfully checked by furrows plowed between the rows of corn. In this case the soil was light and stony and it would have been a difficult matter to make the sides remain perpendicular. The soil being very loose, however, gave way with the weight of the caterpillars as they attempted to climb up the sides, and hence prevented their reaching the top. In this case the furrows were made promptly, and hence nearly the entire crop was saved. The caterpillars were first seen in the field of rye shown on the left.

In pasture fields where the surface of the ground is comparatively even and the soil is firm the caterpillars can be crushed by a heavy roller. Spraying of crops with a strong mixture of Paris green and water may also be resorted to. It is usually unnecessary to spray more than a strip about a rod wide in advance of the caterpillars. Where possible the poisoned portion of the crop should be burned to prevent possible danger of injury to stock. Fig. 2 is from a photograph taken in an infested field of corn showing the work of the poison in protecting the crop. A heavy roller was also used in this field, but the soil was too light for the best results by this method.

* United States Dept. Agri. Report, 1881-2, pp. 90, 91.

A NEW GOOSEBERRY.

A FIRST-CLASS certificate was awarded by the fruit committee of the Royal Horticultural Society at a recent meeting to a gooseberry named Langley Beauty, exhibited by Messrs. James Veitch & Sons, Royal Exotic Nurseries, Chelsea. This seedling variety was raised from a cross between Yellow Champagne and Railway, and is another remarkable instance in which the fruits produced by the seedling exceed in size those upon either of the parents. To illustrate this, a single fruit from each parent is shown in the engraving above the representation of the seedling. It was intended to combine the larger berries of Railway with the upright habit of growth and greater flavor possessed by the latter. This has apparently been done; and, it may

GOOSEBERRY LANGLEY BEAUTY.

A cross between A, Railway, and B, Yellow Champagne.

be added, the fruits of the seedling, besides being of first-rate flavor, are of a yellowish color and handsome in appearance.—The Gardeners' Chronicle.

THE SCHOOLS OF ANCIENT GREECE.

"OF all animals, the boy is the most unmanageable," wrote Plato, more than two thousand years ago, and his view would have been indorsed in our own days by Matthew Arnold, whose views on the barbarian character of the schoolboy are well known. As Plato was a great educational theorist, and Matthew Arnold an inspector of schools, both knew what they were talking about, and they might have shaken hands across the centuries on this, as on many another point. It is certain that both ancients and moderns must have faced many of the same educational questions, chief of which will always be how to turn this embryo savage into a civilized and useful citizen. How the Greeks solved this problem we know in part, and there is no lack of literature on the subject, but unfortunately it is the would-be reformers, and not the practical teachers, whose writings have come down to us, so that we learn more about what ought to be than what actually was. Still here and there in some Greek writer we get a glimpse at school life; now and then a vase painting reveals a school group, or a fortunate discovery brings to light some of the implements actually used in a Greek school. If the naturalist can reconstruct an animal from a single bone, we may surely take the liberty of putting our fragments together and piecing them into a Greek school. That schools existed everywhere throughout Greece is well established, for references to them are very common in the writers, and it is also certain that each generation thought the schools had degenerated since their time, and sighed for the good old days ere boys had learnt to be idle and illmannered.

Each village seems to have had a school, each town doubtless several. There was a terrible story of an athlete who, failing to win a prize at Olympia, was driven mad by disappointment, and in his fury burst into the village school, tore down the pillar that supported the roof, and buried sixty boys in the ruins. As Herodotus has a similar tale of a roof falling in and killing the scholars, we cannot but infer that school architecture in those days was not all that could be desired; in fact, a still extant picture of a school tends to confirm this impression. Sometimes there was no building at all, and master and pupils would sit by the wayside or in some open space to do their lessons. How the pupils were induced to concentrate their attention in spite of the distractions around them we are not told, but can only guess that the master's task was no sinecure. Indeed, the lot of a primary teacher must have been a hard one in many ways. At Athens, and in most other Greek cities, education was a matter of private enterprise. The state passed a few regulations; for instance, that no school must open before sunrise or remain open after sunset, and reserved to itself the right of inspection—that was all. The master provided the room, if there was one, and the apparatus, and made what he could out of the pupils' fees, generally a small pittance. Nor was he compensated for his poverty by an honorable position. When Demosthenes wished to taunt his rival Æschines with his low origin, he reminded him that his father had been a schoolmaster, and that he had helped to sweep out the schoolroom, scrub the benches and mix the ink.

When we talk of Greece in the ancient days we are apt to mean Athens, because from its poets and artists we are better acquainted with that than any other Greek city. But, always excepting Sparta, there was a good deal of resemblance between the different parts of Greece, and the Pan-Hellenic festivals must have encouraged similarity of education among those who were to take part in the contests. Hence we may take a few peeps into the Athenian schools as typical of the rest.

Supposing it is one of the primary schools, there will probably be a number of boys of ages varying from seven to ten. They will meet on their way, and arrive in groups as is the way with modern boys, but they are not trusted to take care of themselves, but are attended by an old slave, known as the pedagogue (paidagogos, boy leader), who will see that his charges do not get into mischief. Arrived at the school, they leave their cloaks in an anteroom, where the pedagogues may wait if they please till lessons are over, and enter a large room where there are a number of little low stools for the boys, and a raised seat for the master. No desks to write at, just a movable stool or bench, and plenty of opportunity for pushing and squabbling for seats, so much more delightful to the boy mind than the unsocial isolation of the single desk. In front of the class stands the white board, perhaps chalked over, though that seems rather a clumsy contrivance. This board must do an immense deal of work, for books are far too expensive for each boy to have a primer of his own to dogsear and draw pictures on. In learning to read, the letters must be written on the board, and the pupils taught to connect sound and shape, then they may copy them for themselves. Thus reading and writing are combined in a manner to which we are gradually returning for pedagogic reasons, and which is supposed to be "the latest thing out" in educational theories. Next the letters are combined into syllables, and this caused sufficient difficulty to make it worth while to invent plans for rendering learning simple and pleasant. A certain Callias, evidently with a desire of composing a sort of "Reading without Tears," wrote what is somewhat unfortunately named a "Tragedy of the Alphabet." It was a regular play, duly divided into prologue, episodes and choruses, and was so arranged that the choruses could be sung to the ordinary melodies, and yet were only a sort of glorified Ba = ba. The prologue introduces the letters as persons, the seven vowels being women. As the seventeen consonants were apparently male characters, the elements of a tragedy were undoubtedly present, but the episodes seem to have contained nothing more thrilling than the divisions of the vowels into long and short, the consonants into mutes, liquids, etc. Tablets on which letters and syllables were graven seem to have been hung up in the schools; a brick, discovered at Athens, has on it ar—bar—gar—er—ber—etc., and must have served as a sort of primer for the class.

The Greek equivalent for our slate was a tablet covered with wax, on which letters were scratched with the sharp end of a style. When they were to be expunged, the broad end, by flattening the wax, rubbed the writing out again. No squeaking noise, no sharpening of slate pencils, no wet sponges. Apparently this was one of the things they did better in Greece. The wax had occasionally to be renewed, but this seems to have been done at home, and the mother or one of the slaves would undertake the job. When children first began to write, the master would sometimes hold and guide their hands, but the commoner plan was that described by Protagoras. (Plato, "Protagoras," p. 326). He says, "the writing master first draws lines with a style for the use of the young beginner, and gives him tablets, and makes him follow the lines." It was usual for the master to write faintly on the wax, and then let the pupil draw over his impress. But this would only be needed by beginners. Afterward the master would write a copy on the board or on a tablet, and the pupil would imitate it. This gave an opportunity for impressing copybook maxims on the youthful mind; but as the Greeks regarded the poets as their greatest teachers, the copies usually consisted of lines of poetry. Some such tablets have actually been found in Egypt, apparently in a schoolmaster's grave, all bearing the same lines from Menander. There is the master's in a firm hand, the boy's more or less well done, and under one—the best—the word Diligent has been written by the master as a mark of approbation.

After reading and writing came arithmetic, and Greek boys were duly drilled in the third of the three R's. Sums on slates were unknown, and would have been almost impossible with the clumsy Greek notation. To them the natural way of counting was with the fingers; gradually they came to replace five strokes

by a rough picture of the hand—V, and this doubled—X—becomes 10. But the ordinary method of counting was with the actual fingers, according as they were bent or placed. The left hand was used to represent all the units and tens, and with the addition of the right hand, all the hundreds and thousands. This was enough for the ordinary purpose of life, and was evidently the common method. But though this represented all the numbers, it would require a great deal of mental helping out, and for more complicated calculations resort was had to a sort of counting machine called an abacus, something like a toy well known in our nurseries and kindergartens. It had several straight furrows in which pebbles or pegs were set, and the value of the pebble varied according to the line in which it was placed. One of these counting boards is represented on an old vase painting; Darius is seated at a table, discussing with his councilors the advisability of going to war with Greece. The tributes from conquered lands are being brought him, and he marks the amounts received on the abacus in front of him. One of these boards, forty inches long and twenty-eight broad, has actually been found at Salamis, and its arrangements appear to be very complicated.

But reading, writing, and arithmetic, though of practical utility, and the necessary groundwork of a higher culture, were of quite subordinate importance compared with the development of the mind, the cultivation of taste, and training in morality. Lucian, in one of his dialogues, puts into the mouth of Solon a discourse on the Athenian education of his day. "When children have learnt to read and write intelligibly," he says, "we sing to them the maxims of the sages and poets, who have clothed in verse the exploits of our ancient heroes, or other useful subjects." The poets were regarded as the chief teachers, and as soon as possible boys must become familiar with suitable selections from their writings. In this instruction oral teaching necessarily played an important part, and the result was a most valuable training of the attention, and a quickness of apprehension apt to be deadened where too much is left to the eye. Much poetry was learnt by heart, simply by repeating the lines which the master read out. When great speed in writing had been acquired the boys took down a good deal from dictation, but this would be impossible at the slow pace of earlier years.

Homer was the chief school book of the Greeks, who regarded his writings as almost inspired. Verse was read before prose, and the fiery hexameters of the "Iliad" and "Odyssey" were an excellent basis for the instruction in pronunciation, melody, rhythm, and accent, all which formed a part of the reading lessons. From Homer, too, they had already received their first ideas of religion, and his stories were familiar to them from their mothers' telling. Then there were moral lessons to be drawn from his poems, which were to them a sort of sacred writing. The tales of brave heroes would kindle their emulation, they learnt of Achilles who hated a lie as the very gates of hell, who, when his loved friend Patroclus fell in battle, scorned to barter honor for life; of wise young Telemachus, obedient to the will of the gods; of faithful Penelope, prudent Odysseus, and many another. Moreover, the "Iliad" and "Odyssey" were regarded as a sort of compendium of all arts and sciences, the guide to all wisdom, a line from which, quoted at random, ought to settle a dispute. Lucian gives an amusing instance of such quotations in his account of a philosopher's banquet. One guest came uninvited, excusing himself with the words:

"But Menelaus uninvited came."

To which the inhospitable host replied from another part of the "Iliad:"

"Howbeit it pleased not Agamemnon's heart."

The pictorial side of teaching was not altogether neglected, and in later and more luxurious days an illustrated Homer for schools seems to have existed. Remains of one such in use in Roman schools were found about two hundred years ago, and are now preserved in the Capitoline Museum at Rome. They are fragments of bass-relief, tablets representing the events of the Trojan war, in the manner in which a series of kindergarten pictures might relate some modern story. Here and there a word helps out the meaning—for instance, Agamemnon, ransom, plague, etc. The pictures seem to have contained all that was necessary for the understanding of the story, not only as told in the Iliad, but as illustrating the whole tale of Troy, both from Homer and other writers. We see Agamemnon repulsing Chryses, who offers a ransom for his daughter, Apollo hastening down from Olympos, wrath in his heart, with bow and quiver, and clanging arrows, to punish the Greeks for their sacrilegious refusal; we see the Greeks stricken by plague, the assembly of the chiefs, Thetis complaining to Zeus of the insult offered

BOWL OF THE FIFTH CENTURY B.C., ILLUSTRATING THE SUBJECTS OF INSTRUCTION.

to her son Achilles, Paris fighting with Menelaus, Ajax with Hector, and many another familiar scene from this tale of tales. The tablet bears the inscription, "Study the Homeric series of Theodoros, that from his teaching you may learn the measure of all wisdom." This appears to be addressed to juvenile spectators, and was almost certainly used in some luxuriously fitted school, though unfortunately in Rome and not in Greece.

If we may assume the existence of such beautiful aids to teaching, it must have gone a long way toward making learning pleasant; but all the testimony we have bears witness to the severity of the discipline in ancient schools. The eloquent strains of Homer and the sweet reasonableness of the master do not seem of themselves to have sufficed to keep the "unmanageable animal" in the right path. The account of current education, put by Plato into the mouth of Protagoras, says that the child must be told what is right and wrong, to do this and abstain from that. "And if he obeys, well and good; if not he is straightened by threats and blows like a piece of warped wood." Allusions to school punishments are not unknown in Greek writers, and a Pompeian wall painting, which, of course, belongs to a late period, actually represents a scene of this kind. The master is flogging a boy, who is hoisted on the shoulders of another, while a third is holding him by his heels. The most striking glimpse of this side of school life as yet afforded us is in one of the newly discovered Mimes of Herodas, which must have been written early in the third century B.C. The scene

A ROMAN TABLET ILLUSTRATING HOMER.

is a primary school in the island of Cos, kept by one Lampriscos. To him there comes a woman leading by the hand her truant son, Cottalos, of whom she tells a woeful tale. He is a typical bad boy, who neglects his lessons, spends his time gambling at "odd and even"—even knuckle-bones do not suffice him; he has forgotten the way to school, and as for that unlucky tablet of his, that his poor mother slaves away to cover with fresh wax every month, it hangs unused by the bedside, and if ever he casts an eye on it, it is only to make it all in a mess again. He cannot recognize the letter A, unless it is shouted five times in his ear. He cannot recite a line of poetry properly, and if his parents venture to say a word, he runs off to his grandmother's, or climbs up on the roof, and sits there with his legs dangling down like a monkey. There he amuses himself smashing the tiles, and his parents have to pay for new ones. She implores Lampriscos, by the love of the gods, to give her boy a good thrashing. Lampriscos consents, and calls three other boys to hoist him on their shoulders, promising to render him "meeker than a maid." Lampriscos flogs, the boy howls and cries for mercy. At last even the schoolmaster relents, but the mother is obdurate, and the scene ends with her request that a further dose of punishment may be dealt out to her hopeful son.

When the primary instruction is ended comes the division of studies under the somewhat puzzling headings—Music and Gymnastic. This really meant mental and physical training. Music was everything over which the Muses presided—that is, song, music (in our acceptation), poetry, and all the arts; gymnastic was the proper training and development of the body. These studies were pursued in two distinct schools, the Mouseion and the Palæstra (the wrestling school). Since we read of boys getting up very early to go to the music school, it is probable that they began the day with music and ended with gymnastic. Happily we possess a picture giving us some insight into one of these schools of the Muses. It is taken from the outside of a bowl painted by Duris, a celebrated artist of the fifth century B.C., and the four groups represented on it illustrate the main subjects of teaching. In the first, the double pipe is in the hands of a master, who is either showing the pupil how to play it, or else giving him the notes he is to sing. It is not clear, however, whether this is a lesson in singing or flute playing, but, of course, both subjects would be taught in this school. The next group represents instruction in writing, apparently with style and tablets, though some kind of pen and ink were already in use. The master is either correcting the boy's work or writing a fresh copy for him. The third subject is instruction in the lyre. Both master and pupil hold instruments in their hands, and the boy is learning to grasp the chords by the fingers of his left hand. The last one represents poetry; the pupil is reciting a poem inscribed on a roll which the master holds in his hands.

Boys in these more advanced schools would have books of their own, for now they could be trusted to use them; besides this, further instruction only fell to the sons of richer citizens who could afford to spend the necessary money in implements. The picture shows various objects hanging on the walls. There is a *roll* of manuscript which can be unrolled as required, as shown in the picture. Next comes a writing tablet, with a string and a handle, then a lyre and a cross, which last has hitherto baffled the ingenuity of the learned. On the other side are two drinking cups, two more lyres, a basket, probably used for keeping manuscripts, and a flute case with a capsule for the mouth piece.

These were all the implements actually needed for instruction on the Muses' side. But as time went on school furniture tended to become more elaborate. A very interesting recent discovery has thrown some fresh light on the interior of a Greek schoolroom, though not in Greece itself. Egypt, that land of mystery, is gradually beginning to give up her hidden treasures, and works that were regarded as lost forever have been recovered there within the last few years. This discovery consists in a fragment of a wooden tablet about three-quarters of an inch in thickness and about twenty inches long, the height varying from three to four inches, browned by age, and bearing marks of contact with linen, which suggest the neighborhood of a mummy. On one side are some lines from Euripides' "Phœnissæ," and on the reverse nearly sixty lines of the "Hecale," one of the most celebrated of Callimachus' poems, of which but a few scraps had hitherto been known by us. The tablet is broken, but at the top a groove may be still be traced, and in this a regular series of holes. There can be little doubt that nails were once fixed in these, so that a cord might be fastened on them, and thus the whole became a reversible tablet, which could be used for lessons in reading or literature, and turned at will, according as the subject was Callimachus or Euripides. This discovery is doubly interesting, both for the light it throws on teaching methods and for the glimpse it affords us of a work which was regarded by the learned as practically lost. They knew that Callimachus had written a whole epic with the title "Hecale," thereby, like so many lawgivers, transgressing his own rule, since he was the author of the oft-quoted saying—"A great book is a great evil." The poem is, as far as we know, a glorification of the old Attic hero Theseus, and Hecale was the name of an hospitable old woman who entertained him with supper and mythology when he was on his way to an encounter with the Marathonian bull. The Euripides side of the tablet is divided into two columns, the Callimachus side into four. A good deal of the lower part is broken away, but as the Phœnissæ are still entirely extant, it is easy to guess how many lines are missing.

The first column describes the return of Theseus from Marathon, leading the bull in chains, and sending word to his father, Ægeus, of the successful accomplishment of his enterprise. The country people crowd round him to express their joy, and welcome him with a shower of blossoms. The second and third columns refer to ancient legends of Athens, which might well be regarded as episodes in an epic celebrating an Attic hero. In the fourth column we seem to meet Hecale herself, but even this is uncertain. In fact, the amount of literature supplied by this tablet to the general reader is not considerable, but it is invaluable to the scholar, both for what it gives and still more for the wide field of speculation opened up by its omissions.

Perhaps the greatest boon it confers is the hope of more. If this tablet has really lain in a grave, as we know that the wax writing tablets did, how many more similar treasures may there not be in store for us in the Egyptian tombs!

We need not wonder at the care and labor bestowed on any instruction that dealt with the literary or musical side of education. Far less was done to train the hand, since manual work belonged to slaves. Aristotle was the first to recognize drawing as a school subject, and it gradually made way in schools, but the aim was to train the appreciation of the beautiful and by no means to prepare for a craft. To a modern mind, surveying the subjects of a Greek time table, there seems a long list of omissions—e. g., languages, science and manual instruction. But these would have been considered not only useless, but even immoral. A cultivated Greek would have disdained to study the language of his barbarian neighbors; an orthodox citizen shrank from the interpretation of natural phenomena; a freeman would scorn to know the trade of a slave. To learn the right employment of leisure was, in Aristotle's view, the whole aim of education, and for this purpose a thorough knowledge and appreciation of their own language and literature were requisite—no small task when we remember what the Greek language and literature include. Besides this, to sing a song creditably to his own accompaniment, to speak gracefully and eloquently, to listen courteously, to criticise competently, were the demands made by the Muses on a Greek gentleman.

But there was yet another deity who had a claim on him, Hermes, the patron of youth and inventor of the wrestling school. The object of the training there given is thus described by Solon (in Lucian): "By making our youth, after they have passed the tender age, and their limbs have acquired proper strength and firmness, wrestle naked, we propose in the first place to inure them to the open air and familiarize them with all seasons and weathers. Then they are trained in the usual gymnastic arts, to harden the body and render it more insensible to pain and suffering." But except among the Spartans, this hardening was hardly the main object, for the development of grace was as important as that of strength. Grace of mind and of body were desired by the Greeks. Mere undigested learning and brute strength were objects of ridicule to them.

In the wrestling school the exercises included jumping, running, throwing the quoit and spear and wrestling. Various elaborate ball games were also popular in the schools, and dancing was of first importance, on account of the training required by a chorus in the plays.

Greek boys seem to have had their fair share of holidays, even a little more sometimes, if it is true that stingy parents would keep their boys at home during the month in which there happened to be a good many festivals to avoid paying the fees. Of course there could have been no lessons during the hot months of summer. There were some festivals which were specially celebrated in schools—for instance, those of the Muses in the music school and of Hermes in the gymnastic school. It was on one of these occasions that Socrates visited the wrestling school with Ctesippus, and found "the boys all dressed in white, many having wreaths on their heads. Most of them were in the outer court amusing themselves, but some were in a corner of the Apodyterium, playing at odd and even with a number of dice which they took out of a little wicker basket."

These wrestling schools were private undertakings like the others, but when boys got to about sixteen, and had had their elementary gymnastic training, they might go on to practice in the beautiful gymnasia supplied for the youths by the state. Here they found the most elaborate arrangements, combining wrestling place, racecourse, baths, oiling rooms, covered corridors, etc. Here were teachers for every kind of exercise, many of which now assumed a military character, and special trainers for those who desired to compete at the Olympic or any other of the great games. Higher instruction in literary subjects could also be obtained by those who could pay for it, and the sophists, who usually supplied it, seem to have demanded and received tolerably high fees. At the age of seventeen or eighteen the youths were considered ready to serve their country, and were sent to do a kind of patrol duty on the frontier. The transition from boyhood to youth is marked by a solemn ceremony. The boyish dress is discarded and the short military cloak and broad-brimmed hat are put on. The hair is cut short, and the shorn locks dedicated to one of the gods; then the boys, henceforth to be known as youths (Ephebi), assemble in the theater to be presented to the people, and here they receive their spear and shield and take their oath of allegiance to the state:

"I will never disgrace these hallowed weapons or abandon my comrade, beside whomsoever I am placed, and I will fight for both sacred and common things personally, and with my fellows.

"I will not leave my country less, but greater and better by sea and land than I may have received it.

"I will obey the rulers for the time being, and obey the established laws, and whatsoever the commonwealth may agree to establish; and if any one abolish the ordinances, or disobey them, I will not allow it, but will defend them personally, and with the rest.

"I will obey the established religion."

While the boys are being transformed from mischievous urchins into useful citizens, what are the girls doing? Probably helping their mothers to cook or sew and making themselves useful at home. Of intellectual training they seem to have had very little. The Greeks had not a very high opinion of women, and it was probably the common view of them that was expressed by Aristotle when he said: "Females are tenderer, and more mischievous and less straightforward, more hasty and more given to thought for their offspring; but males, on the other hand, are more spirited, fiercer and more straightforward and less treacherous. A woman exceeds a man in pitifulness, and in her tendency to tears, but on the other hand she is more given to envy and censoriousness, to abusiveness and blows." That it never occurred to Aristotle that some of these faults might be removed by the education which he regarded as so important for boys, almost makes us doubt whether he really did know everything. Plato would have given girls the same education as boys, but that was an Utopian dream never carried into practice. In Sparta, where the state took some thought for the teaching of girls, and where women were held in greater honor, morality was far higher than at Athens, and it remains the greatest blot on the general system of Greek education that by educating only half the race they made it impossible even for that half to lead a really virtuous and noble life.—Alice Zimmern, in Leisure Hour.

THE INSPECTION AND SANITARY ANALYSIS OF ICE.*

By Prof. CHARLES L. KENNICOTT.

THE use of ice for preserving foods and cooling drinks, thus making life more endurable during the heat of summer, is perhaps more general in this country than any other.

From the fact that ice was observed to be clear when frozen on bodies of water more or less turbid, it was generally supposed that in freezing water became purified. In regard to the grosser particles and some of the dissolved solids, this is true; for example, ice containing 1·30 parts per 100,000 of total solids was taken from Lake Hooker, Wis., the water of which contained 27·90 parts per 100,000 of total solids. But during the last few years, bacteriological research has shown that ice teems with dormant cellular life, and that it is just as dangerous to use ice from a sewage contaminated source as to draw a water supply from a polluted stream. The danger of disease infection from polluted ice having been but lately recognized, we are not surprised to find that those engaged in the ice industry have paid but little, if any, attention to sanitary conditions, but cut ice with a special view to transportation facilities.

In addition to natural ice, cut from rivers, lakes and ponds, the manufacture of artificial ice, by means of the heat absorbed in the evaporation of a liquefied gas, is now in general practical operation.

A possible third source of supply, but one hardly to be considered from a practical point of view, was mentioned some time ago in our daily papers to the effect that a company had been formed to capture icebergs and tow them into New York Harbor, there to be cut up and sold for cooling purposes. Within the past year the city council of the city of Chicago, recognizing the dangerous properties of impure ice, passed an ordinance prohibiting the storage or sale of such ice and providing for its enforcement through the Department of Health.

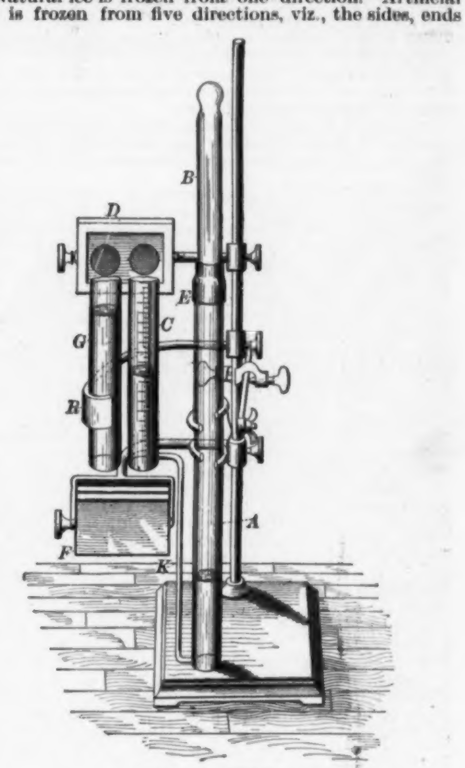
The sources of the contamination of ice, other than the original contamination of the water from which it is cut, are many. In the first place, the hay, straw or sawdust, covering the pile of ice blocks in the ice house, may be a source of infection. The cars in which ice is transported are often filthy, having been used to carry manure, brewery slop, etc. After the arrival of the ice in the city, the wagons which convey the ice to the consumer are, as a rule, in a very unsanitary condition. The men in charge of them do not hesitate to walk in the wagons with muddy boots, and grasping a piece of ice with a pair of tongs, slide it across the sidewalk, which may be covered with the sputa of beings suffering from various diseases, and then proceed to wash it with water from the same bucket with which the horses are watered.

Lest my hearers should think that I exaggerate the dangers as herein stated, let me remind them that among our foods ice occupies a peculiar position. Unlike other foods, ice cannot be boiled or cooked and cannot even be thoroughly washed, being of a porous nature.

Artificial ice may be subject to the same chances of infection, except contamination by sewage, for there is no excuse for any manufacturer making ice from polluted water. A greater part of the artificial ice is frozen from distilled water. The distilled water generally used, or at least a part of it, is condensed from the engines, and therefore contains a trace of cylinder oil. On this account, after being distilled and reboiled, it is passed through a charcoal filter. This is objectionable, for a charcoal filter once infected would become a breeding place for bacteria, and thus pollute instead of cleanse all water which subsequently passed through it. If it were not for removing oil, there would be no necessity for using filters for water already distilled.

Many consumers of artificial ice complain that it melts faster than natural ice, but there is little ground for this complaint, the difference in the rate of melting being very slight. This slight difference in the rate of melting is probably due to one or more of three causes: a low specific heat, a difference in temperature or some difference in physical structure. Probably the latter, as tests of temperature showed differences so slight as to fall within the limits of error of experiment. A difference in specific heat, if such a thing is possible, would not of necessity change the rate of melting, although the amount of heat absorbed would be less.

Natural ice is frozen from one direction. Artificial ice is frozen from five directions, viz., the sides, ends and bottom of the can. As water freezes it expands, and each successive layer of ice must become subject to stress in forcing itself into position as the block forms. To quote Prof. J. Thomson (Proc. Roy. Soc., December, 1861): "Any stress whatever tending to change the form of ice must impart to the ice a tendency to melt away." This would seem to be an explanation of the more rapid melting of artificial ice. In my own experiments I find that the difference in rate of melting is so small that it is difficult to measure.



COLORIMETER.

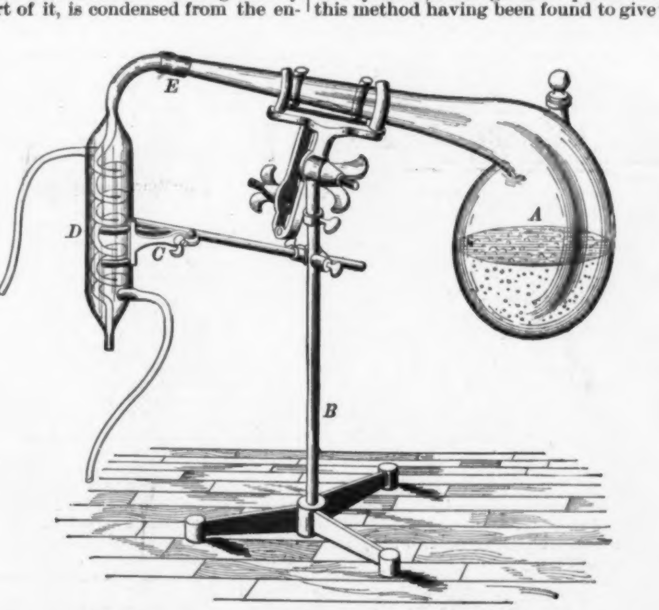
We have adopted the following methods for the analysis of ice in the Municipal Laboratory at Chicago:

Samples are collected in square galvanized iron cans, holding a cubic foot; each can is half filled with distilled water to be used in washing the sample when it is collected; the can and distilled water are then sterilized in a steam chamber.

Upon delivery of the sample at the laboratory, a sample of about five kilogrammes is taken in the form of a cylinder, cutting from top to bottom of the cake, this method having been found to give the best average sample. The cylinder of ice is now washed with distilled water and placed in a percolator or museum jar to melt. The analysis should be commenced as soon as possible after the sample is melted, as changes from nitrites to nitrates or albuminoid to free ammonia take place much more rapidly in melted ice after the water has become warm than in waters. The organisms producing the changes seeming to be more active after hibernation.

It would, perhaps, be well at this time to describe some of the apparatus used in these analyses.

The apparatus here shown for the distillation of



AMMONIA DETERMINATION APPARATUS.

* A paper read before the American Chemical Society at the Buffalo meeting, August 21, 1896.

water in the determination of ammonia has been in use in the laboratory for three years and has given good satisfaction. It consists of the 32 ounce retort, A, which has been etched on the inside at the botton with a fluoride etching ink. This etching makes a great number of fine points on the glass from which a cloud of small bubbles rises during the ebullition, thus preventing bumping. The retort is clamped to the retort stand, B, in an inclined position, so that particles thrown off by the violent boiling will flow back. The condenser, D, which is held by a clamp, C, and is connected with the retort at E by rubber bands, consists of a glass worm in a glass jacket. The outside measurements of the condenser jacket being seven inches in length by two and one-half inches in diameter. The great advantage of this apparatus lies in the fact that it occupies so much less space than the apparatus which uses the long Liebig condenser.

In practice a bank of sixteen retorts and condensers is used. With this number one attendant can make from forty to sixty ammonia determinations in seven hours.

The colorimeter in use consists of a reservoir, A, a plunger, B, and a tube, C, graduated from 1 cubic centimeter to 100 cubic centimeters, connected as shown in the illustration, by means of a glass tube, K. The plunger is held in place by a rubber band at E. At F and D are two mirrors, pivoted, as shown in the cut. The lower mirror serves to throw light up through the tube, G, containing the solution under examination. This tube is graduated 25, 50, 75 and 100 cubic centimeters, and through the graduated tube, C. The upper mirror serves to receive the reflections of the tubes, G and C. The tube, G, is held by the spring clamp, R, which is lined with felt.

To use the apparatus, fill the tube, G, to the desired mark with the dilute solution under examination, and the tube, C, and a part of the reservoir with the standard solution. Raise or lower the plunger until the colors of the liquids in the tubes reflected in the upper mirror are the same. Note the volume in the tube, C, and make the necessary calculation.

Total Solids.—Evaporate 500 c. c. of the melted ice nearly to dryness on an asbestos board over a lamp flame. Heat in the air bath at 105° C. until it ceases to lose weight, and weigh.

Loss on Ignition.—Ignite the total solids at a low red heat, cool and weigh. The loss in weight is the loss on ignition.

Chlorine.—Solutions required: A, 4·789 gms. C. P. crystallized $AgNO_3$ dissolved in 1,000 c. c. of distilled water. Each c. c. of this solution equals one milligramme of chlorine. B, 5 gms. potassium chromate dissolved in 100 c. c. of distilled water and a weak solution of argentic nitrate dropped in until a slight permanent precipitate is formed.

Measure into a flask 100 c. c. to 200 c. c. of the sample. Add four drops of the solution B as indicator. Titrate with argentic nitrate A until a faint red color appears, which indicates the end of the reaction. Perform the same operation with distilled water as a blank and make correction by subtracting the number of c. c. used in distilled water from the number of c. c. used in the sample.

Free Ammonia.—Solutions required: A, a 20 per cent. solution of recently ignited C. P. sodium carbonate. B, dissolve 200 gms. C. P. potassium hydrate and 8 gms. C. P. $K_2Mn_2O_8$ in 1,200 c. c. distilled water; boil rapidly until concentrated to 1,000 c. c. Cool and keep in a well stoppered bottle.

C. Ammonia Free Water.—Put 500 c. c. of distilled water in the retort and add 5 c. c. sodium carbonate solution (A); distill until the distillate gives no reaction for ammonia with Nessler's solution. Now save the distillate for ammonia free water until about 100 c. c. remains, then empty retort.

D. Nessler's Solution.—Dissolve 35 gms. of potassium iodide in 100 c. c. of water. Dissolve 17 gms. of mercuric chloride in 300 c. c. of water. The mercuric chloride solution may be heated if it does not dissolve easily, but must be cooled before use. Set aside about 10 c. c. of the potassium iodide solution. Add the mecuric chloride solution to the potassium iodide solution until a red precipitate is formed. Add 200 gms. of KOH, and when cool make up to 1000 c. c. with distilled water. Keep in a glass stoppered bottle away from ammonia fumes. It is well to grease the stopper with a little vaseline to prevent it sticking.

E. Standard Ammonium Chloride.—Dissolve 15·75 gms. of C. P. ammonium chloride, dried over sulphuric acid in a desiccator, in 1,000 c. c. of ammonia free water. For use dilute 10 c. c. of this solution to 1,000 c. c. with ammonia free water. Each c. c. of the diluted solution will then contain 0·00005 gm. H_3N, or 0·00004117 gm. nitrogen.

Place in the retort, which has now been cleaned by boiling out in the preparation of ammonia free water, 500 c. c. of the sample; add 2 c. c. of the sodium carbonate solution A and distill 200 c.c. into two or more of the tubes provided with the colorimeter, and set aside.

Albuminoid Ammonia.—After the distillation of the free ammonia remove the lamp and add to the water remaining in the retort 25 c. c. of the alkaline permanganate solution B, replace the lamp and distill 200 c. c. in the tubes provided. This gives the albuminoid ammonia.

Calculating the Results.—The amounts of ammonia in the two distillates, i. e., free and albuminoid ammonias, must now be determined. This is accomplished by means of the ammonium chloride solution E, Nessler's solution D and the colorimeter.

To make a standard solution for the colorimeter measure 10 c. c. of the ammonium chloride solution E into a 250 c. c. flask and dilute nearly to the mark with ammonia free water; now add 5 c. c. of Nessler's solution, mix and dilute to the mark. Fill the colorimeter with this solution. To each of the tubes containing distillates under examination add 2 c. c. of Nessler's solution. Stir with a glass rod and let stand 5 minutes. Now place a tube in its clamp in the colorimeter and raise or lower the plunger until the tints of yellow reflected in the upper mirror are the same. Take the reading and calculate as follows: Multiply the number of c. c. in the graduated tube giving the same tint as the tubes for either free or albuminoid ammonia by the factor 0·0004. This gives the free or albuminoid ammonia in parts per 100,000.

Oxygen Consumed.—Solutions required: A, dissolve 0·325 gm. C. P. $K_2Mn_2O_8$ in 1,000 c. c. of distilled water. 1 c. c. of this solution contains 0·0001 gm. available oxygen; B, one part by volume of C. P. sulphuric acid is mixed with three parts by volume of distilled water and a solution of potassium permanganate dropped in until the whole remains a very faint pink after standing a few hours; C, dissolve 4·0317 gms. of ammonio-ferrous sulphate in 1,000 c. c. of distilled water made slightly acid with sulphuric acid.

The Process.—Measure 100 c. c. of the sample into a carefully cleaned 500 c. c. flask, add 25 c. c. of the permanganate solution A and 1 c. c. of the sulphuric acid solution B. Place on the hot plate and boil just 10 minutes; proceed at once while still hot and titrate the excess of permanganate with the ammonio-ferrous sulphate solution C. Each c. c. of solution A decomposed by boiling is equivalent to 0·100 part per 100,000 of oxygen consumed.

A blank with distilled water had best be run at the same time as the determination, and the necessary corrections made.

Nitrates and Nitrites.—Solutions required: A, a saturated solution of sulphoanilic acid in water; B, a saturated solution of naphthalamine in dilute hydrochloric acid; C, C. P. hydrochloric acid; D, powdered metallic magnesium; E, 2·030 gms. of pure dry silver nitrite dissolved in hot water. Add pure sodium chloride as long as a precipitate forms; dilute to 1,000 c. c. with water, and set aside to deposit its silver chloride; 100 c. c. of the clear liquid are then diluted to 1,000 c. c. 1 c. c. of this solution contains 0·00005 N_2O_3, or 0·000018424 gm. nitrogen.

The Process (Nitrites).—(These tests had best be made before the water from the melted ice has time to get warm.) Fill a 100 c. c. comparison tube with the sample to be examined, add four drops of each of solutions A, B, and C in the order named. Let stand ten minutes. If nitrites are present, a pink color will appear. If it is desired to determine the amount of the nitrites, make a standard solution for the colorimeter by diluting 1 c. c. of the sodium nitrite solution E to 200 c. c. with distilled water, and use colorimeter in the same manner as described under the determination of ammonia.

The Process (Nitrates).—Add $\frac{1}{10}$ grm. of powdered magnesium to the tube containing the tests for the nitrites, mix by pouring from one tube to another an let stand. This will reduce the nitrates, if present, to nitrites and a red color will appear. If nitrites were present, measure the increase in depth of color by means of the colorimeter and calculate as nitrates.

The interpretation of an ice analysis is even more difficult than that of a water analysis, if that be possible. Ice in its journey from the ice pond to the ice chest of the consumer is subject to peculiar conditions in regard to source of supply and particularly to methods of packing and handling. It is necessary after ice is packed in the ice house to cover the pile of ice blocks with some material which will keep away air currents and, at the same time, be a good non-conductor of heat. Sawdust is objectionable, because when ice melts particles sink into the block. Straw gives a yellow color to the ice. Clean hay is undoubtedly best, but often musty hay discarded as unfit food for cattle is used because it is cheap. There is no excuse for unclean ice wagons. It would seem that a wagon lined with sheet iron which could be easily washed would have preference over soggy wood which had absorbed contamination ever since it had been in use and may have become a breeding ground for bacteria.

The opinion as to the sanitary quality of an ice sample must, as in a water analysis, be drawn from all available data taken as a whole. The limits of the ammonias will, if anything, be made more stringent for ice than for water. Ice containing nitrites is, undoubtedly, of a suspicious quality, and should not be used in contact with articles of food and drink. There is generally but little more than a trace of chlorine in ice, say but one or two-tenths per 100,000.

The oxygen consumed seems to be quite constant in pure ice, and is of more value than in a water analysis, pure ice seldom giving more than one-tenth part per 100,000 of oxygen consumed.

Artificial ice occupies the same position in regard to natural ice that artesian water bears to other waters, that is, as far as free ammonia is concerned. Free ammonia absorbed in small amounts from the air of the freezing room of the ice factory may appear as a large amount when measured with delicate chemical means and expressed in the figures of a water analysis. Upon this alone artificial ice should certainly not be condemned, although, if the albuminoid ammonia is high, organic contamination is probably present.

Natural ice should be cut from an unpolluted source, artificial ice frozen from pure water. Ice should be stored and handled as carefully as any other food, transported in special cars used for no other purpose, and carried to the consumer in wagons carefully cleaned before each loading.

A word in regard to a common practice seen in any of our large cities. I refer to the dropping of ice upon the streets or sidewalks. That this practice is highly objectionable need not be said. Each wagon could carry a frame of boards or a tray of sheet iron upon which to drop the ice and not allow it to absorb the filth of our city streets.

The boards of health of our cities are responsible to a large degree for the health and, therefore, the happiness of our citizens. The inspection of food and drink is now in general operation, but the regulation of ice supplies is in need of further attention. Pure ice ordinances should be enacted where laws are not now in existence, and in addition to this must be rigidly enforced.

According to a description in a Kansas City paper of the box industry in that locality, there is one factory alone which has an annual output of two and one-half million boxes, most of which are used by the packing houses and soap manufacturers, one packing house using 267 different styles of boxes, another 100, and so on. Candy and cracker makers, starch factories, extract makers, and other manufacturers use a vast number of boxes of various sizes and styles suited to their goods. Then, in addition to the box factories, are the shook factories, which turn out millions of "knocked down" boxes annually, one factory using 12,000,000 feet of cottonwood lumber annually, this coming from Arkansas.

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